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COUPLED TIME LAPSE PHOTOGRAPHY AND PHOTOGRAMMETRY FOR HIGH PRECISION MAPPING OF HUMAN BEHAVIOR IN ETHNOARCHAEOLOGICAL RESEARCH

ABSTRACT: Ethnoarchaeological studies attempt to link human behavior to material remains for the purpose of developing archaeological method and theory. Traditional studies in spatial ethnoarchaeology have focused on mapping features and refuse, but the spatial distribution of the behaviors that produced them, the thing that interests us most, has for good reason gone largely undocumented. Until recently, it was not technically possible to map people in space in a way that is simultaneously accurate, precise, and unobtrusive. In this paper, we discuss the use of time-lapse photography and photogrammetry for the direct, frequent, and high precision mapping of human behavior in ethnographic contexts. Using two experiments, we show that this method can produce human locational data that are accurate and have submeter precision, typically of 25 cm or less. We illustrate the utility of this method by examining how the exterior space of a camp of Dukha reindeer herders in northern Mongolia is divided by household. We argue this method provides much needed data on how humans use space while allowing for the collection of ancillary behavioral and contextual information from imagery. As such, time-lapse photography and photogrammetry could become part of the standard toolkit for ethnoarchaeological research.

KEY WORDS: Ethnoarchaeology – Photogrammetry – Time lapse photography – Mapping – Spatial analysis

INTRODUCTION

Here we discuss our development and use of coupled time lapse photography and photogrammetry for high precision mapping of human behavior in ethnographic contexts. We employed this data collection method in the Dukha Ethnoarchaeological Project, a study of the spatial distribution of human behavior and its determinants in campsites of Dukha reindeer herders in Mongolia for the purpose of developing method and theory for application to archaeological spatial patterns with particular emphasis on hunter-gatherer archaeology

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(Haas *et al.* 2018, 2019, Mackie *et al.* 2015, O'Brien *et al.* 2022, O'Brien, Surovell 2017, Surovell *et al.* 2022, Surovell, O'Brien 2016). The impetus for the development of this method was to overcome what we felt were two shortcomings of prior approaches to spatial studies in ethnoarchaeology.

First, if the intent of ethnoarchaeology is to link variation in human behavior with its material correlates to develop middle range theory (Binford 1978a, 1981), ethnoarchaeological studies require some measurement of the behaviors of interest. Traditional studies of ethnoarchaeology with a focus on space, however, largely lacked any direct measurement of the spatial distribution of human behavior other than broad generalities about how spaces were used (Bartram *et al.* 1991, Brooks, Yellen 1987, Fisher, Strickland 1989, Haakanson 2000, O’Connell 1987, O'Connell *et al.* 1991, Simms 1997, Spurling, Hayden 1984, Yellen 1977). Many of these studies, for example, generated highly detailed maps of spaces in which humans lived, built structures, used hearths, and discarded refuse, but lacking from those studies is the spatial distribution of the behavior that generated those physical remains. Researchers clearly recognized the importance of such data (Binford 1978b, 1983), but the absence this kind of data collection was largely a result of a lack the technology to do so.

Second, as first noted by O'Connell (1987: 104), most of the spatial patterns recognized in ethnoarchaeological studies occur at scales significantly greater than those at which archaeologists excavate sites. A typical contiguous excavation area in an archaeological site spans 10^1 – 10^2 m^2, while spatial patterns identified in ethnoarchaeological studies occur at larger scales (10^3 – 10^4 m^2). Nonetheless, a myriad of patterns exist in the archaeological record at the scale of excavation, patterns associated with hearth-centered activity areas being one obvious example (e.g., Andrews *et al.* 2021, Audouze, Enloe 1997, Binford 1978b, Laughlin 2005, Leesch *et al.* 2010, Leroi-Gourhan, Brézillon 1966, Mackie *et al.* 2022, Nakazawa 2007, Sergant *et al.* 2006, Shahack-Gross *et al.* 2014, Stapert 1989, 1991, Stapert, Johansen 1995, Stevenson 1985, Surovell 2022, Surovell, Waguespack 2007). In other words, there is often a scalar mismatch between the phenomena studied archaeologically and ethnographically. We argue that by studying the spatial distribution of human behavior directly using methods capable of mapping persons with relatively high precision, we can bring spatial ethnoarchaeology down to the scale of archaeological excavation.

While our focus here is on the technique and its utility, it is important to highlight a shift in methods regarding mapping campsites. Debris may be more analogous to archaeological material culture, but the use of modern technology among contemporary foragers has significantly reduced the rate of discard in campsite settings. For example, a mapping of debris from a 2017 Dukha Fall Camp resulted in an observed density of .008 objects per m^2, similar to a result report by Yellen (1977: 88) for San campsites. We suspect that artifact densities from Stone Age archaeological sites are much higher as a general principle than those of living and recent peoples because the manufacture and maintenance of stone tools in the past resulted in much higher densities of artifacts left behind. Although multiple factors contribute to spatial distributions of chipped stone in archaeological sites, the first is where people choose to do things. Therefore, by gaining insight into where people choose to do things and how those spatial decisions are made, we believe we can develop theory for understanding archaeological distributions of chipped stone and other types of material remains.

In this paper, we describe mapping human locations in ethnographic settings with coupled time lapse photography and photogrammetry, its development, and our experiences using it. We then present two experiments used to establish the accuracy and precision of the method. Finally, we illustrate the utility of the method using a simple case study of how exterior spaces of campsites are used by members of different households.

MAPPING HUMAN BEHAVIOR WITH COUPLED TIME LAPSE PHOTOGRAPHY AND PHOTOGRAMMETRY

At the outset of the Dukha Ethnoarchaeological Project, we had several goals and constraints. First, we wanted to create a dataset suitable for use as an analog to hunter-gatherer archaeological sites whose spatial patterns are typically present at the scale of meters (Surovell, O'Brien 2016), so we needed a method capable of mapping human locations with submeter precision. Beyond our research goals, we faced several practical constraints. Minimizing weight and maximizing portability were crucial because the equipment used needed to be transported by airplane, vehicle, and on pack animals to reach our field sites in remote areas of the Sayan Mountains of Mongolia. We needed the system to be energy-efficient, since our only option for generating energy in the field was solar panels. Because we were working with human subjects, we needed the system to be unobtrusive, so as not to seriously affect the phenomenon of interest, the spatial distribution of behavior. Ideally, the system would allow us to determine the positions of multiple individuals within camp spaces at relatively frequent intervals to generate sufficient sample sizes to allow meaningful characterization of the spatial distribution of behavior. Finally, because we live in an era of rapid technological change, to situate this paper into its temporal and technological context, our first field season was in the summer of 2012 and our last was in the fall of 2017.

Prior to selecting coupled time lapse photography and photogrammetry as our primary method of data collection, we considered two other options, GPS trackers and local positioning systems. Small GPS tracking devices were available at the time and have been used in other ethnographic contexts (e.g., Wood *et al.* 2021). We incorporated them into our research design during our final field season, but we decided against this approach as our primary mapping method because the data generated have insufficient spatial precision for our research goals. Most GPS receivers, for example, provide locations with at best 2 to 4 m precision, and often considerably worse. In real world terms, if a person was inside a Dukha household, typically a conical lodge called an ortzen ger with an average diameter of around 4 m, it would be impossible to know, for example, if that person was inside or outside of that structure using a GPS tracker alone. We wanted to know not only whether an individual was inside but also the specific part of the house they occupied. One problem with this example is that we did not use time lapse photography to map individuals within interior spaces, but instead turned to a complementary method of observational mapping described elsewhere (Haas *et al.* 2018, O'Brien *et al.* 2022, Surovell *et al.* 2022). We only use this example here for illustrative purposes. We also briefly considered the possibility of using a local positioning system (Gulden *et al.* 2009), a system analogous to a global positioning system that is typically used to track things in indoor spaces, like factories or warehouses. At the time and still today, however, we knew of no such system that could be adapted to a dynamic ethnographic context.

For these reasons, we turned to time lapse photography and photogrammetry for mapping exterior spaces. The time lapse camera system allowed us to capture outdoor camp scenes at frequent intervals, and photogrammetric software allowed mapping of individuals, animals, and objects on ground surfaces within those photos. We first describe our time lapse system and then our photogrammetric methods.

Time Lapse Camera System

Our time lapse camera system consisted of a telescopic mast, a waterproof box, and a camera with a timelapse controller. The camera was elevated to provide overhead oblique views of camp scenes (*Figure 1*). To lift the camera system, we used a telescopic fiberglass mast (Hilomast Corporation, model PFC 7.5) that extends to 7.5 m in height and collapses to 1.9 m in length for transport. It weighs 5.9 kg. We initially used long metal stakes with six guy lines to secure the mast but later turned to handmade wooden stakes or natural anchors (e.g., roots or trees). During our first field season, a horse became tangled in the guy lines causing the mast and camera to crash to the ground. On the advice of our Dukha friends, we switched to handmade wooden stakes made by our collaborators and never had this problem again. The University of Wyoming Engineering Shop built a mounting mechanism for the time lapse system that allowed us to adjust the tilt of the camera once mounted to the mast. For our first two field seasons that incorporated this kind of mapping (2012 and 2014), we used a time lapse camera system manufactured by Harbortronic Corporation in Fort Collins, Colorado, USA (*Figure 1a*). That system used a digital SLR camera (Canon EOS Rebel T3) with an 18 mm wide angle lens with the shutter controlled by an external programmable time lapse controller. The system was powered by lithium polymer batteries charged by a solar panel mounted to the top of the box. The system, except for the panel, was housed in a waterproof box with a hinged door with a glass window. We had frequent technical difficulties with this system, so we transitioned to a simpler system for our last three field seasons (2015, 2016, and 2017). The time lapse system required programming in the DOS operating system, and we found it to be quite finicky. There was no way to monitor the state of the battery, so the system would stop working at unpredictable times. This system was designed to be used over months taking only a few photographs per day, so the energy requirements of our application exceeded what the system was designed to do. After switching systems, we used the same weatherproof box from Harbortronics but paired it with a Nikon D7200 digital SLR camera with an internal time lapse controller and 18 mm wide angle lens (*Figure 1b*). We supplemented the camera's internal battery with an external battery back (Nikon MB-D15) that used AA batteries. This allowed us to leave the camera operational during long summer days (up to 16 hours) or cold winter days (temperatures below -40°C). During our winter field season, we used Energizer lithium-ion batteries due to higher efficiency at cold temperatures; in other seasons, we used rechargeable Panasonic Eneloop nickel-metal hydride batteries.

When using a time lapse camera system, there are a few additional considerations. We always brought an extra camera in case one was lost or broken. Another is time lapse interval. We experimented with various intervals but ultimately settled on a three-minute interval. For a 12-hour day, this interval would generate 360 photographs. Obviously, shorter intervals generate more data, but camera batteries and memory cards are more quickly exhausted. Video would have been an ideal solution, but the energy and memory requirements would have been even greater. It is also critical that moisture is eliminated inside of the weatherproof camera housing to prevent fogging on the camera lens and the window of the box. We kept a ready supply of dry silica packets in our field gear for this purpose. Another consideration is camera positioning. We always chose a location in consultation with our Dukha collaborators, but for our system, a distance 25 to 30 m away from focal areas seemed to work well.

Photogrammetry

Photogrammetry is the process of mapping or measuring from photographic images. We did not use 3D or structure from motion photogrammetry, a method

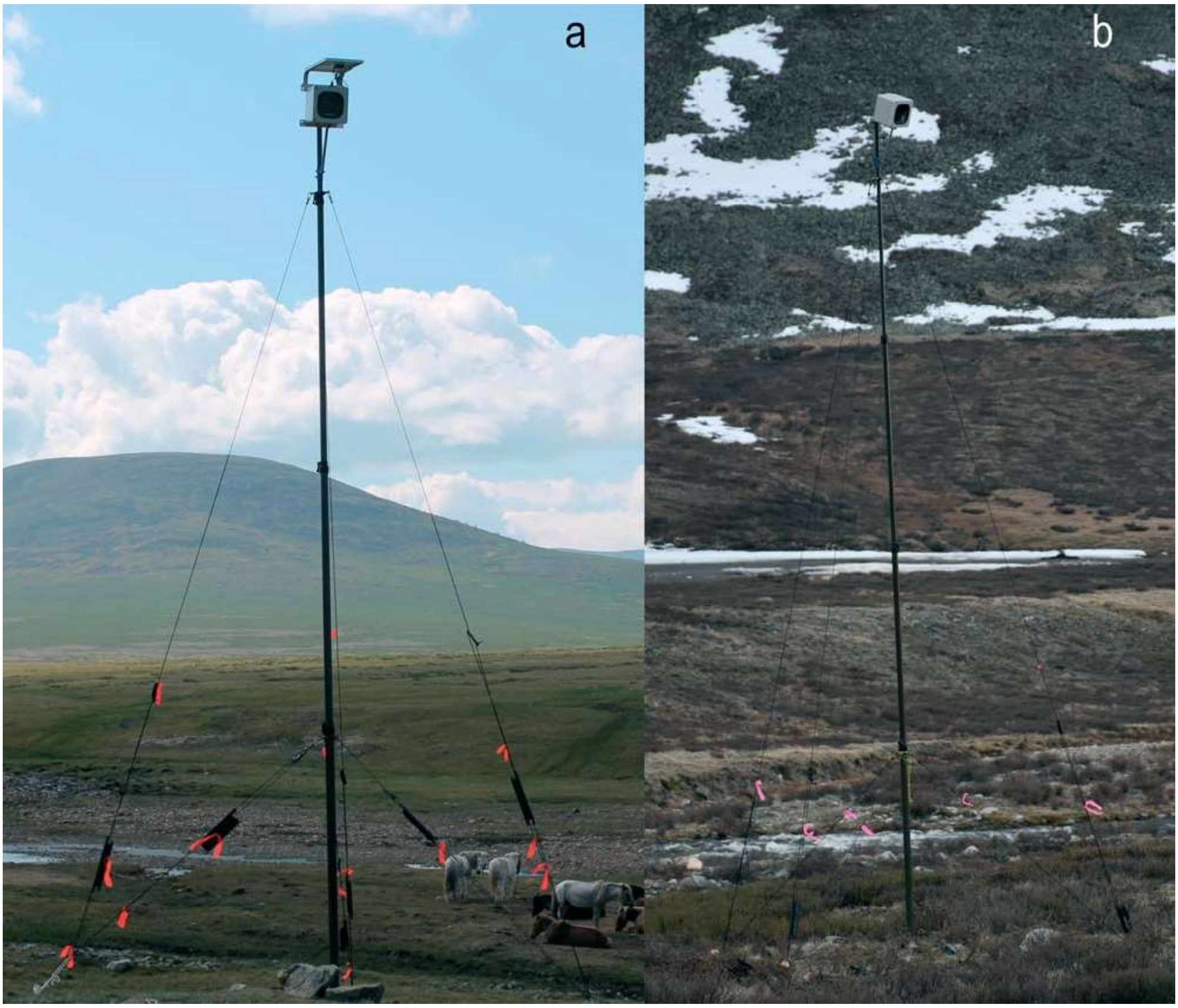
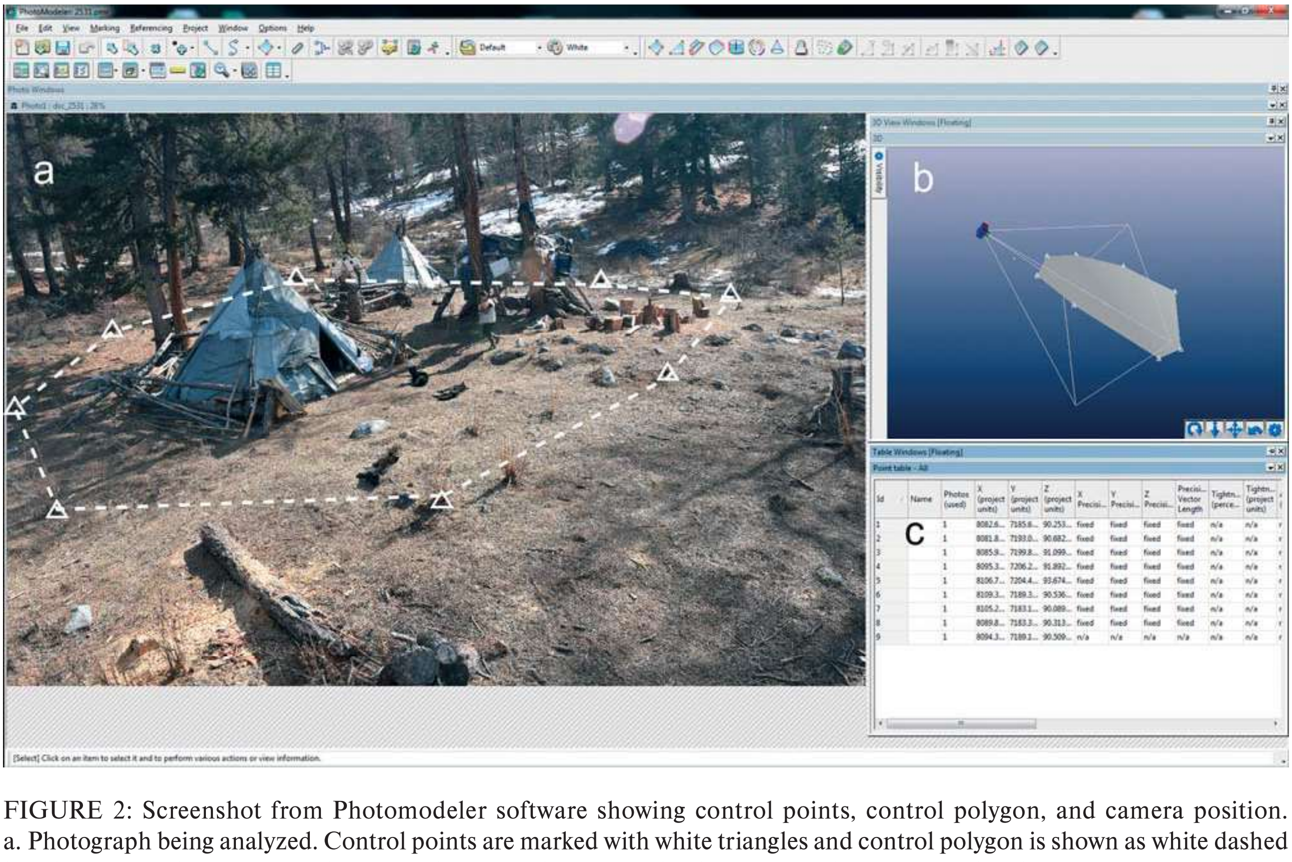


FIGURE 1: Time lapse camera system used in 2012 and 2014 (a) and 2015 and later (b).

that has become commonplace in archaeology for generating three-dimensional models of sites and objects (e.g., Anderson 1982, Douglass *et al*. 2015, Howland *et al*. 2014, Koenig *et al*. 2017, Magnani *et al*. 2020, Marín-Buzón *et al*. 2021, Sapirstein, Murray 2017, Willis *et al*. 2016). Our approach was two-dimensional because there was no practical way to implement a 3D solution, and a 2D method sufficed for our research goals. Applications of 2D photogrammetric methods in archaeology are also common in archaeology, for example the digital measurement of lithic artifacts or rock art from scaled photographs taken orthogonally to the object of interest (e.g., Buchanan *et al*. 2007, 2018, Buchanan, Collard 2010, Cadieux 2013, Guthrie 2005, Mackie 2015, Snow 2006). Our approach is similar, except that it does not require the camera to be positioned orthogonally, or at a right angle, to the scene to be mapped. It also uses surveyed ground control points to determine locations and distances instead of a metric scale.

We used Photomodeler software (v. 2012) for our photogrammetric data collection. For a typical 2D application like ours, Photomodeler requires at least five control points of known Cartesian coordinates on the ground surface. We used six to ten control points depending upon the scene. In our first field season, when we worked in a summer camp with sparse alpine tundra vegetation, we used yellow plastic tent stakes hammered into the ground until flush as control points. In later seasons, we used flagging tape tied to vegetation, wooden stakes, or other fixed objects. Although total stations are common to archaeological projects, the delicate nature of these systems made them less than ideal for the rigors of remote fieldwork involving pack animals. Initially, we mapped the position of control points using a builder's level surveying instrument and determined coordinates trigonometrically using distance and bearing. In later field seasons we used a Trimble GNSS receiver (model R2) and data collector (model Nomad) with real time correction and submeter precision.



Id	Name	Photos (used)	X (project units)	Y (project units)	Z (project units)	X Precisi...	Y Precisi...	Z Precisi...	Precisi... Vector Length	Tightn... (perce...	Tighten... (project units)
1		1	8082.6...	7185.8...	90.253...	fixed	fixed	fixed	fixed	n/a	n/a
2		1	8081.8...	7193.0...	90.682...	fixed	fixed	fixed	fixed	n/a	n/a
3		1	8085.9...	7199.8...	91.099...	fixed	fixed	fixed	fixed	n/a	n/a
4		1	8095.3...	7206.2...	91.892...	fixed	fixed	fixed	fixed	n/a	n/a
5		1	8106.7...	7204.4...	93.674...	fixed	fixed	fixed	fixed	n/a	n/a
6		1	8109.3...	7189.3...	90.536...	fixed	fixed	fixed	fixed	n/a	n/a
7		1	8105.2...	7183.1...	90.089...	fixed	fixed	fixed	fixed	n/a	n/a
8		1	8089.8...	7183.3...	90.313...	fixed	fixed	fixed	fixed	n/a	n/a
9		1	8094.3...	7189.1...	90.509...	n/a	n/a	n/a	n/a	n/a	n/a

FIGURE 2: Screenshot from Photomodeler software showing control points, control polygon, and camera position. a. Photograph being analyzed. Control points are marked with white triangles and control polygon is shown as white dashed line. b. 3D view showing control points (white triangles), control polygon (gray plane), extrapolated camera position (camera icon) and field of view (white lines). c. control point coordinates

We refer to the area within the polygon defined by the control points as the "control polygon". Photomodeler software uses the known coordinates of the control points to interpolate the positions of mapping points on the ground surface within the control polygon and extrapolate positions outside of that polygon. It also solves for the location of the camera from the locations of the control points within photographs (*Figure 2*). Once the location of the camera is solved and a surface is defined, points are mapped. We always mapped the locations of individuals in photographs. We also recorded locations of dogs, reindeer, and occasionally physical objects like houses, work areas, or other features. For each datapoint, we recorded a series of additional information including the time, date, identity of the person mapped (and associated demographic information), activity being performed, posture of the individual (e.g., sitting, standing, walking), and equipment in use.

TESTING THE METHOD

Experiment 1: Total Station vs Photogrammetry

To evaluate the accuracy and precision of this method for mapping, we completed an experiment comparing locations measured by total station and photogrammetry. Total station measurements are considered accurate and were used to determine the x and y coordinates of the control points. Control points and mapping points were chalk marks placed on the asphalt of the parking lot of the Anthropology Building at the University of Wyoming (*Figure 3*). The control area was defined by eight control points creating an octagonal polygon encompassing an area of 230.6 m^2. Within the control polygon, we placed 13 mapping points for measurement using both methods, and another eight mapping points were placed outside of the polygon. Mapping points spanned 34 m north to south and 19 m east to west.

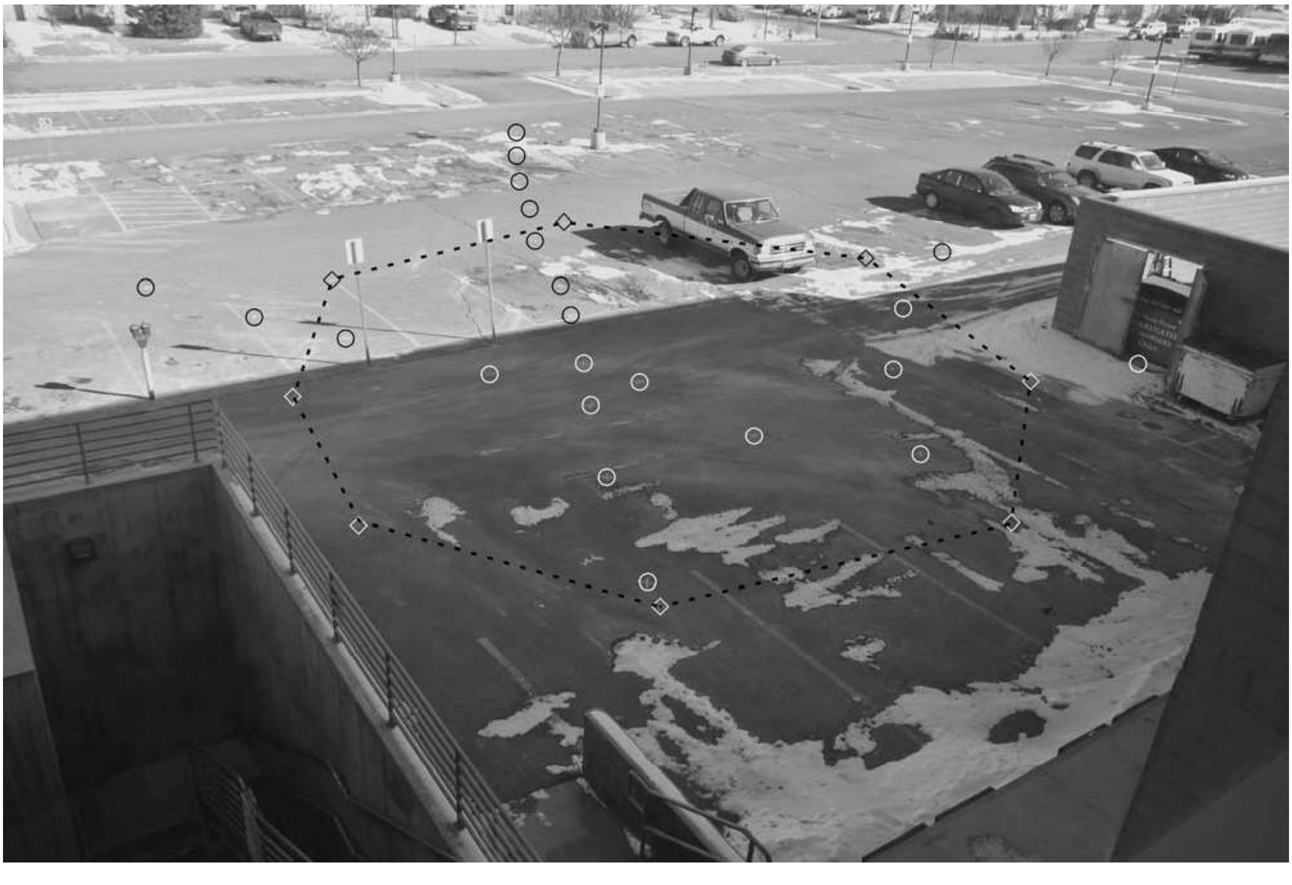


FIGURE 3: Experiment 1 location and setup in the parking lot of the Anthropology Building at the University of Wyoming. Diamonds show locations of control points. Circles show locations of mapping points.

In *Figure 4*, we present a map comparing measured locations of points using the total station and photogrammetric methods. To test the accuracy of photogrammetry, we performed paired t-tests on northing and easting coordinates measured by both methods and found no significant differences (northing: t=0.830, df=20, p=0.416; easting: t=0.698, df=20, p=0.493). To estimate the precision of the photogrammetry method, we calculated error as the two-dimensional Euclidean distance between the measured and actual positions, measured by total station, of mapping points (*Figure 5a*). Errors ranged from 1.4 to 63.3 cm overall for all mapping points. The mean error is 14.6±16.0 cm (mean±s). We found significant differences for errors within and outside of the control polygon (*Figure 5a*). The mean error for mapping points inside of the control points was 8.0±6.2 cm (mean±s). (One outlier in this group has an error of 25 cm. The total station measurement on this point was hampered by a car that parked on our experiment as it was underway, so the total station shot had to be extrapolated from a nearby point. If that point is excluded, the mean error drops to 6.6 cm.) Outside of the control polygon, the mean error was 25.2±21.3 cm (mean±s). We also compared the distance of each mapping point to the control polygon with its associated error and found that these variables are likely correlated (r=0.69, df=6, p=0.058) (*Figure 5b*). Using linear regression, we can estimate that error increases by approximately 3 cm for every meter moved away from the edge of the control polygon.

Experiment 2: Repeated Measurement of Fixed Points in Time Lapse Images

Another way to assess the precision of the method is to repeatedly measure the location of fixed points, like stones or tree roots, in time lapse scenes. For this experiment, we selected three fixed measurement points in photos from a Dukha winter camp and another three from a spring camp. We photogrammetrically measured the location of those points in 20 different photos. We then calculated a centroid for each measured point and determined error as the standard deviation of distance from that point for all 20 photos. For some photographs, only a subset of control points is visible because of obstructed views, so the control polygon was created with only those points that were visible. Views were obstructed by people, animals, snow, or other objects. Thus, we present error estimates for both the total set of images (*Figure 6a*) and for subsets for which all control points are visible (*Table 1, Figure 6b*).

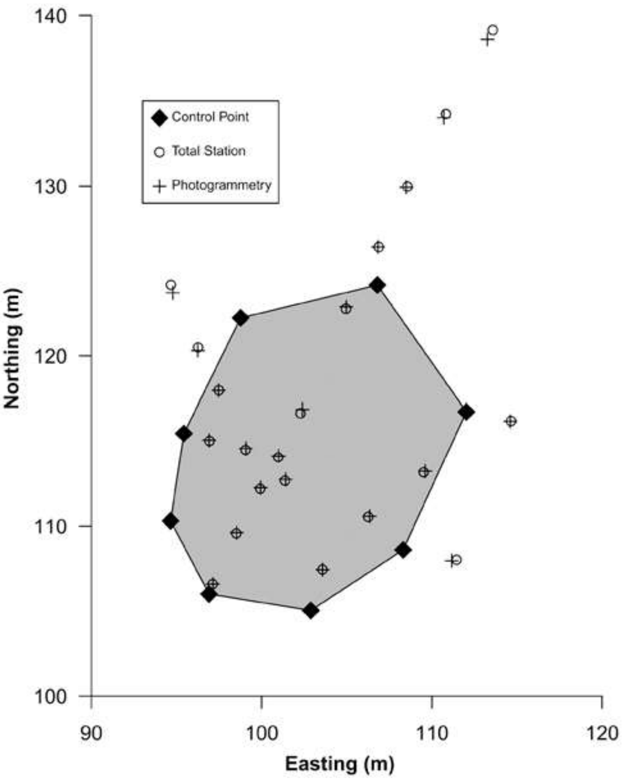


FIGURE 4: Map of experimental study area showing locations of control points, control polygon (gray), and points mapped by total station and photogrammetry.

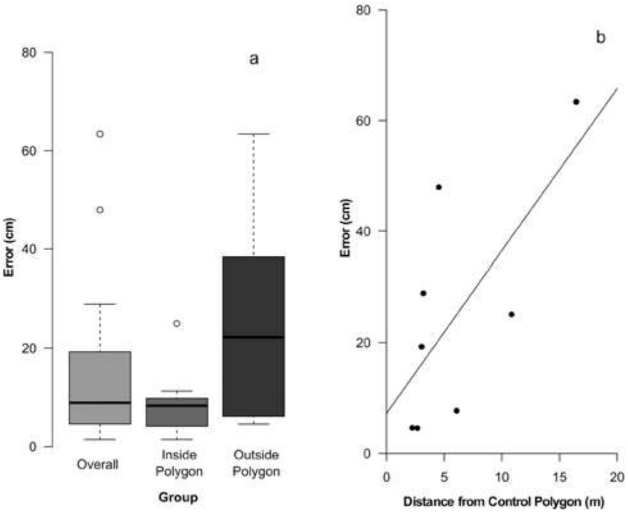


FIGURE 5: Error of the photogrammetric method in Experiment 1. a. Boxplots showing the distance between the measured and actual position of mapping points for all points and those within and outside of the control polygon. b. Error vs. distance from control polygon for mapping points outside of the polygon.

TABLE 1: Measured errors for mapping points recorded in 20 different photographs from a spring and winter camp for photos in which some or all control points are visible.

Point	**Some CPS Visible Error (±s cm)**	**All CPS Visible Error (±s cm)**
Spring 1	11.7	2.0 (n=12)
Spring 2	34.0	17.1 (n=12)
Spring 3	33.2	7.5 (n=12)
Winter 1	7.8	2.0 (n=12)
Winter 2	7.6	5.5 (n=12)
Winter 3	11.7	4.7 (n=12)

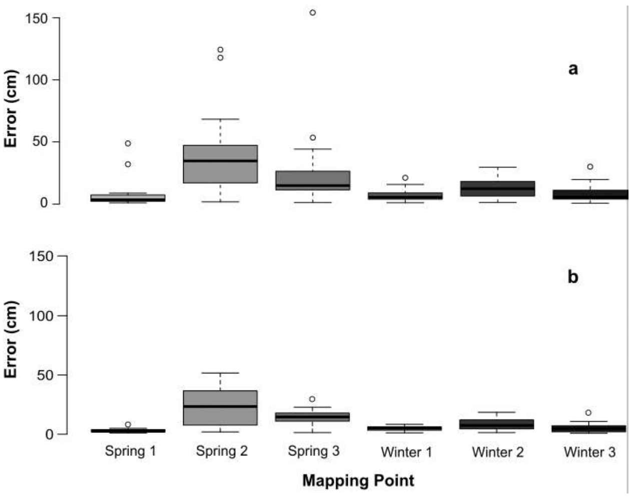


FIGURE 6: Boxplots of error for six fixed mapping points measured repeatedly in time lapse scenes. a. All measurements, including those in which some control points are not visible (n=20). b. Measurements for which all control points are visible (n=12).

The total range of errors was 0.1 to 154 cm. In other words, in the worst case, for a single measurement, by this method, we achieved precision of 1.5 m. For only those photos for which all control points were visible (*Figure 6b*), errors ranged from 0.1 cm to 51.6 cm meaning that in conditions where the photo is well controlled, the worst precision achieved was around 0.5 m. That said, the great majority of points showed much lower errors (*Table 1*). Our error estimate for all points combined was ±23.1 cm, and for photos for which all control points were visible, it was ±10.6 cm. In *Table 1* and *Figure 6*, we show error estimates for all six points, and in most cases, we can achieve errors of less than 20 cm. Importantly for critical measurements, the problem of limited visibility of control points can be overcome by digitally overlaying a photo in which all control points are visible onto one where one or more control points is not visible and using the overlying photo to determine control point locations.

Case Study: Division of External Camp Space by Household

As a simple demonstration of the value of these kinds of data, we turn to an example using data we collected from a Dukha fall camp. This camp was in the headwaters of Higdege River at an elevation of 2,115 masl. These data were collected between September 14 and October 13, 2014. Two families lived in this camp in ortzen ger (conical lodges). In one house lived a married couple, their two sons, one daughter, and a grandson. A married couple and their son lived in the neighboring house. In addition to houses, each family maintained their own cache platforms for storing goods, woodpiles, and staked areas for securing reindeer to be milked (*Figure 7*)

In this example, we test the hypothesis that there is a *de facto* division of exterior camp space by household, and that proximity to each household determines the likelihood of individuals from each household using that space. We expect individuals from House 1 to preferentially use outside spaces nearest to House 1, and individuals from House 2 to preferentially use outside spaces nearest to House 2. Archaeologically, this analysis has implications for assigning artifacts in exterior spaces of sites to the households from which they were derived.

To test this hypothesis, we determined the household affiliation of every individual observed in exterior space. We then divided the camp into two spaces divided by a line equidistant from the centroid of each household (*Figure 7*). Finally, we tallied the number of individuals from each household on each household's side of the camp (*Figure 8*). This includes a total of 3,462 observations (Household 1 n=1,679; Household 2 n=1,783). Importantly, individuals from both households were observed in all areas of camp, but as expected, there is strong bias for individuals from each household to

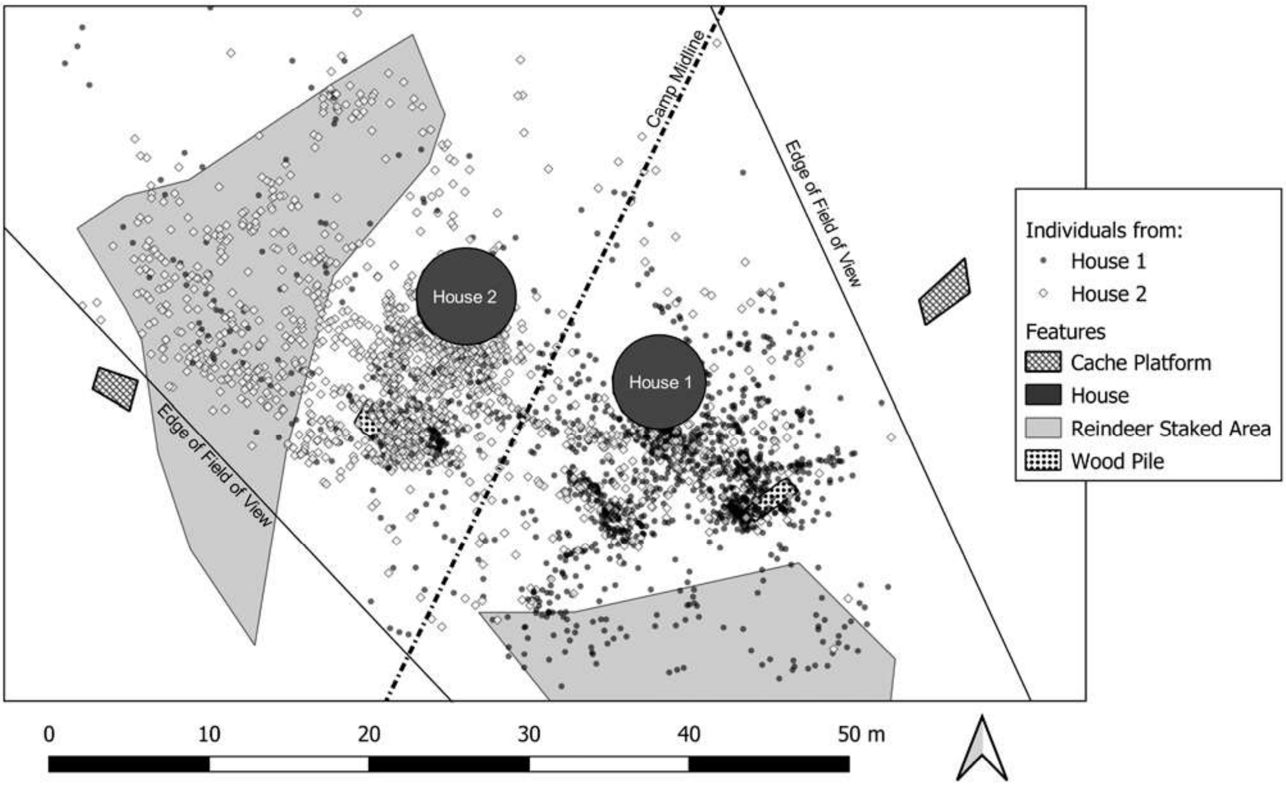


FIGURE 7: Map of a Dukha fall camp from 2014 with locations of individuals marked by household membership. Also shown are features including houses, cache platforms, and reindeer areas. Margins of field of view are shown, as is a line bisecting camp that is equidistant from the centroids of the houses.

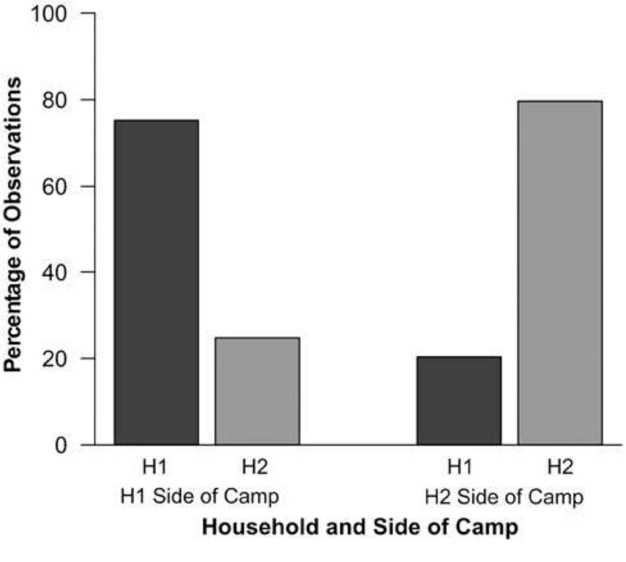


FIGURE 8: The percentage of observations of individuals of each household on each household's side of camp.

preferentially be located on their own respective sides of camp. On the west side of camp, the side closest to House 2, 79.6% of observations of individuals are from House 2. On House 1's side of camp, 75.2% of observations are of individuals from House 1. These patterns are highly significant (Fisher's exact p<<0.001). There is thus clear evidence that individuals preferentially use those exterior portions of their campsites closest to their own household. While not entirely surprising, one can easily envision how small, foundational behavioral inferences of this sort might be used to inform a wide range of anthropological research questions.

DISCUSSION AND CONCLUSION

Coupled time lapse photography and photogrammetry provides an energy efficient, cost effective, and portable means of mapping human behavior in ethnographic field contexts in a way that is accurate, precise, and unobtrusive. Because data collection is based on photographic imagery, there are additional data that can be collected beyond location including aspects of identity, activity, and equipment in use. Objects and animals can be mapped, and other kinds of information can be gleaned from imagery. For example, we were able to use time lapse imagery to determine seasonal changes in the relative frequency with which house doors were left open, something that dramatically affects the amount and distribution of light in houses (see O'Brien *et al.* 2022).

Although there are many benefits to this method, it is not without problems. One downside of this mapping technique is that blind spots are created by visual obstructions. People inside houses cannot be mapped; nor can people behind houses. This effect can be seen clearly in *Figure 7* in which there are linear areas behind houses where there are no individuals mapped. Another downside is the absence of nighttime data. While it might be possible to continue using the system at night, we chose not to do so because limited outdoor activity happens at night, and we chose to prioritize efficient use of batteries over allowing the system to run for 24 hours to collect limited additional observations.

Another issue to consider when using this system is privacy of research subjects. Some reviewers of grant proposals for this project were concerned about what they perceived to be the use of what might be portrayed as a "surveillance system" to document Dukha campsites. Protecting the privacy and wellbeing of our research collaborators was paramount to us, and our project went through multiple rounds of review by the University of Wyoming Institutional Review Board to ensure that we had safeguards in place to prevent harm to Dukha participants. All individuals involved in the study were informed about our methods of data collection and had the opportunity to prevent its use. Camera locations were chosen in collaboration with our collaborators. Most importantly, all time lapse photos were shown to our collaborators, and they had the right to request that any photo be deleted immediately and without question. In the course of the project, during which more than 23,000 photos were taken, we were only asked to delete three. Anthropologists have used many methods for recording aspects of human lifeways including photography, video, audio recordings, and written notes, and the potential to harm research subjects exists no matter what method of data collection is used. What is important is that safeguards are in place to prevent injury to the people we study.

In sum, we argue that coupled time lapse photography and photogrammetry is a valuable tool for spatial ethnoarchaeological studies to document how exterior spaces are used and how people make decisions about where to perform activities. The method is accurate and precise. Our experiments show that submeter precision can be reliably attained, and in most cases, the locations of individuals can be mapped with 25 cm precision or better. Our example showing how the exterior space of a Dukha campsite is divided by household provides one example of the kinds of analyses that can be completed, but the possibilities beyond that are limitless. To provide a few more examples, we could, for example, examine use of space by individuals of different ages or genders. We can examine the spatial distribution of different activities or where different tools are used. We could compare use of space by time of day, season, or weather condition. And all these analyses could have important implications for understanding archaeological spatial patterning. Ultimately, we hope to see additional applications of this method to other ethnographic settings to allow a greater understanding of cross-cultural uses of space at scales relevant to archaeological excavation.

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