Integrating the Differential Global Positioning System and Geographic Information Systems for Mapping and Analysis of Skeletal Dispersals

Brittany Walter, BA[1], John J. Schultz, PhD[1], and Ronald Murdock, MFS[2]

[1]University of Central Florida, Department of Anthropology, Orlando FL/[2]Orange County Sheriff's Office, Forensic Unit, Orlando, FL

ABSTRACT

The purpose of this presentation is to discuss the practicality of using differential global positioning systems (DGPS) in mapping scattered human remains and also to provide recommendations concerning data collection and the integration of DGPS scene data into a geographic information system (GIS). A simulated scene was assembled with a widely scattered partial skeleton in an urban environment. A Trimble GeoXH GeoExplorer 2008 Series DGPS and a Trimble Zephyr antenna with reported decimeter accuracy was used to map the scene. The first data collection used an average of 50 readings at 1-second intervals, and the second used an average of 100 readings at 1-second intervals. Data were post-processed and exported into ArcGIS 10 for analysis. It was determined that, overall, the most accurate method for positional information of skeletal elements was using processed data with an average collection time of 100 seconds for both tree cover obstructed and unobstructed areas. However, the 50-second collection time was found to be sufficient in unobstructed areas for mapping a skeletal dispersal. Furthermore, it is recommended to map individual features when bones are at least 25 cm apart, and map clusters of two or more bones that are less than 25 cm apart as one feature. Finally, maps generated by the collected DGPS data were found to be successful in displaying and analyzing locational and attribute information of skeletal dispersals.

INTRODUCTION

Scene mapping is an integral part of processing a scene with scattered skeletal remains. By utilizing the appropriate mapping technique, investigators can accurately document the location of human remains and maintain a precise geospatial record of this evidence and additional features at the scene. The determination of the appropriate mapping technique can be influenced by the extent of the skeletal dispersal as well as the environment. While baseline and grid mapping methods are typically used for smaller scenes, compass survey or total station methods may be used for mapping skeletal dispersals. Another mapping option is DGPS, as common units now provide decreased positional error suitable for mapping skeletal dispersals. As forensic archaeology is becoming more integrated into forensic anthropology, controlled research is essential to determine the benefits of this technology. The purpose of this presentation is to discuss the practicality of using DGPS in mapping scattered human remains. Also, recommendations concerning data collection and the integration of DGPS scene data into a GIS will be discussed.

MATERIALS AND METHODS

Differential Global Positioning System Theory

The global positioning system (GPS) is a satellite-based positioning system involving twenty-four satellites circling the earth that uses positional information from these satellites to calculate the position of a point. A DGPS is a more accurate enhancement of a standard GPS that requires two receivers; one remains stationary while the other records positional data. The stationary receiver, a base station, relates all of the satellite measurements onto a single local reference. The base station measures the timing errors and provides correction information to the other receiver. In differential post-processing, the basestation information can be obtained via the internet through post-processing software and then compared to the mapped point data for increased positional accuracy **(Figure1)**. The GPS geospatial data is commonly integrated into a GIS program which allows the user to display and analyze the mapped scene **(Figure 1)**.

Simulated Scene

A simulated scene was assembled with a widely scattered partial skeleton in an urban environment on the University of Central Florida campus. A Trimble GeoXH GeoExplorer 2008 Series DGPS with a Trimble Zephyr antenna **(Figure 2)**, which can produce up to 10 cm accuracy with post-processing, was used. The first data collection used an average of 50 readings at 1-second intervals, and the second data collection used an average of 100 readings at 1-second intervals **(Figure 3)**. The data were then post-processed using GPS Pathfinder Office **(Figure 4)** and exported into ArcGIS 10 for analysis. After the data were exported into ArcGIS 10 **(Figures 5** and **6)**, the distance of the unprocessed and processed points were measured. The points were then further categorized as open areas or tree-covered areas.

Cluster Analysis

The determination of collecting proximate bones as separate features or as a single feature was also considered. Bones were measured at distances of 10 cm, 15 cm, 20 cm, 25 cm, and 30 cm to determine the best data collection method of clustered skeletal elements.

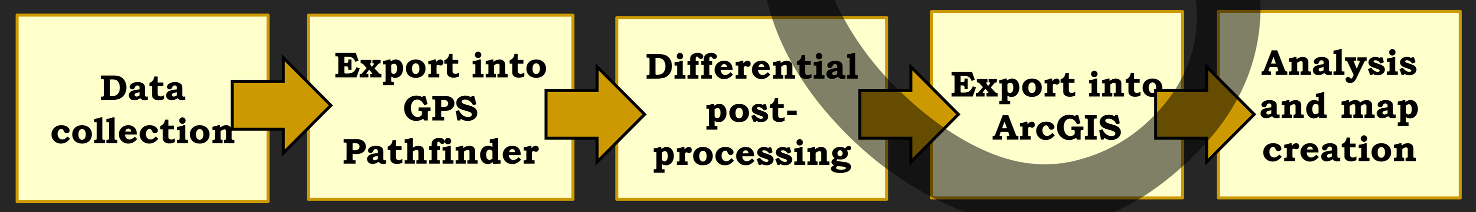

Figure 1: Flow chart of data collection and processing methods

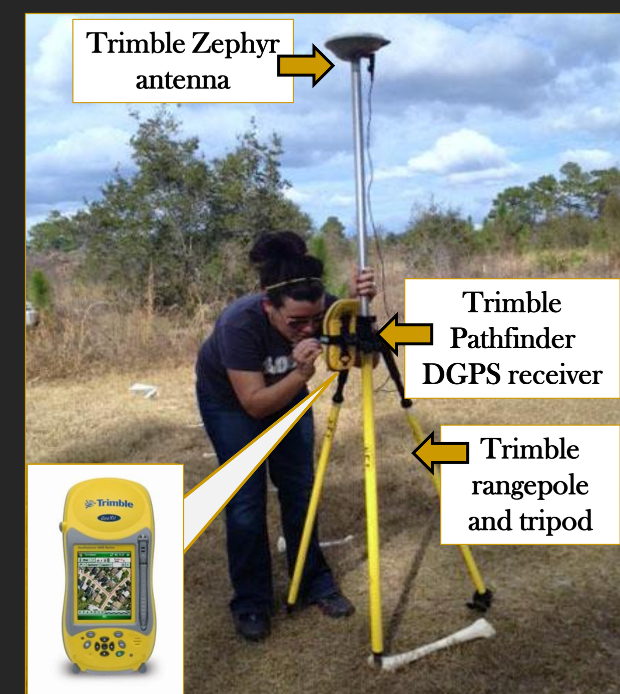

Figure 2: Image of GeoXH GeoExplorer 2008 Series DGPS with antenna, receiver, and rangepole labeled

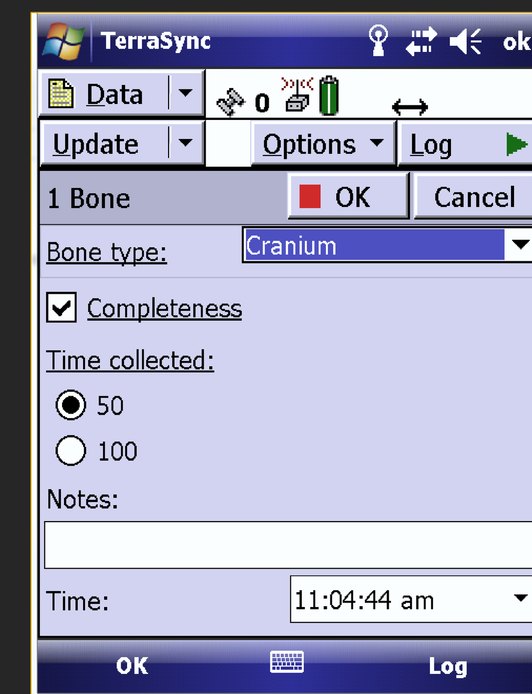

Figure 3: Screenshot from DGPS unit of attribute data input and point collection

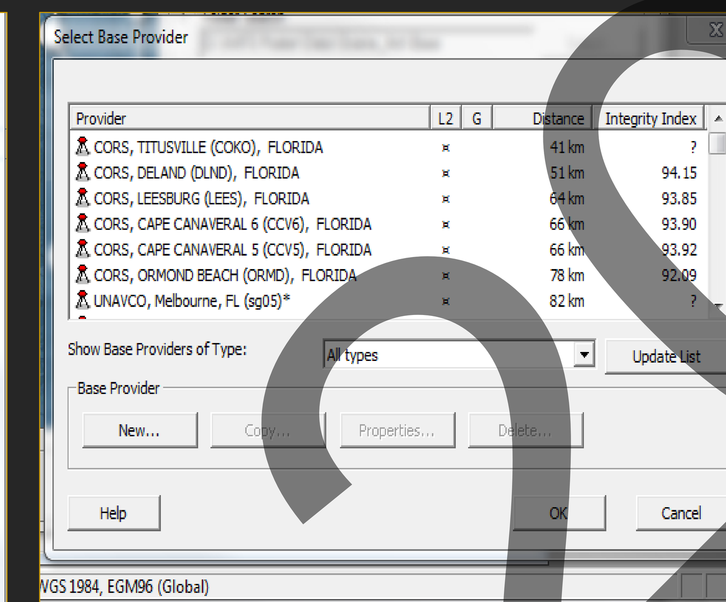

Figure 4: Screenshot of differential post-processing using GPS Pathfinder Office

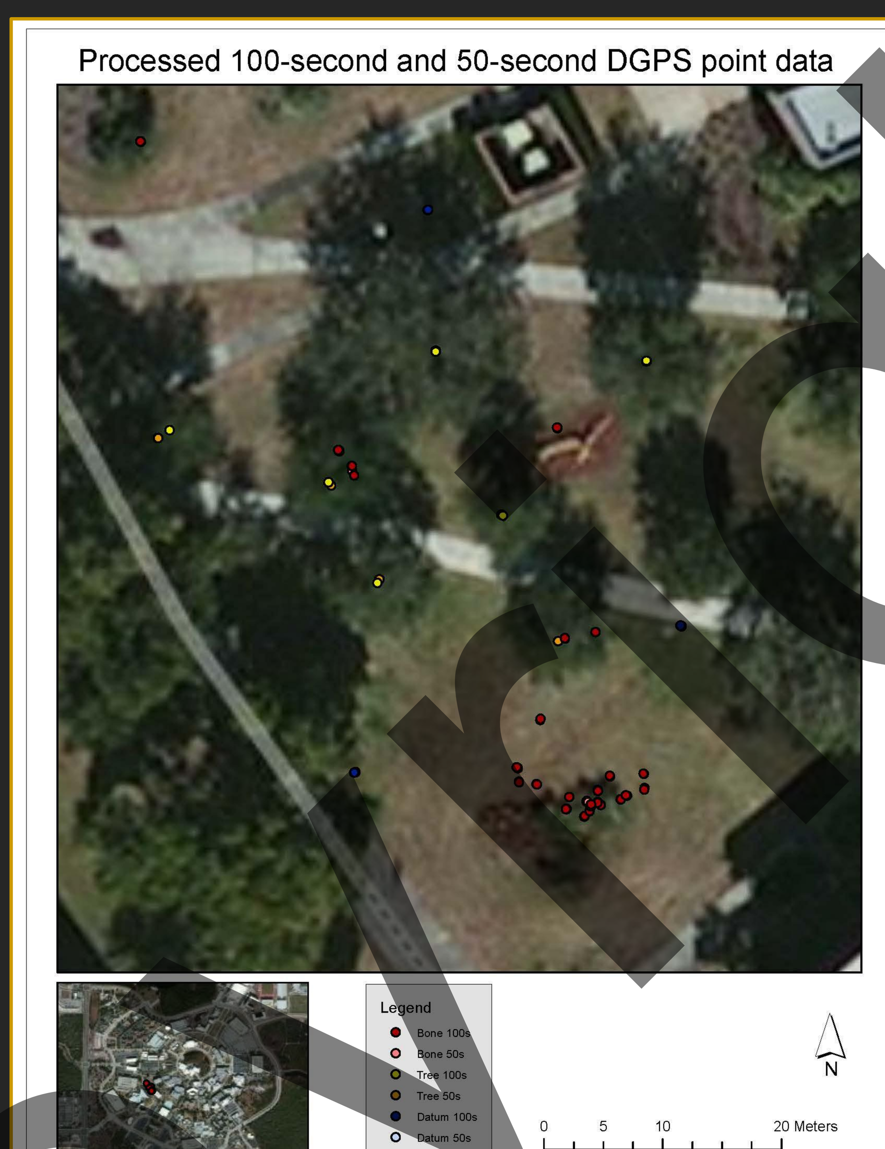

Figure 5: Map of processed 100–second and 50-second DGPS point data using ArcGIS 10

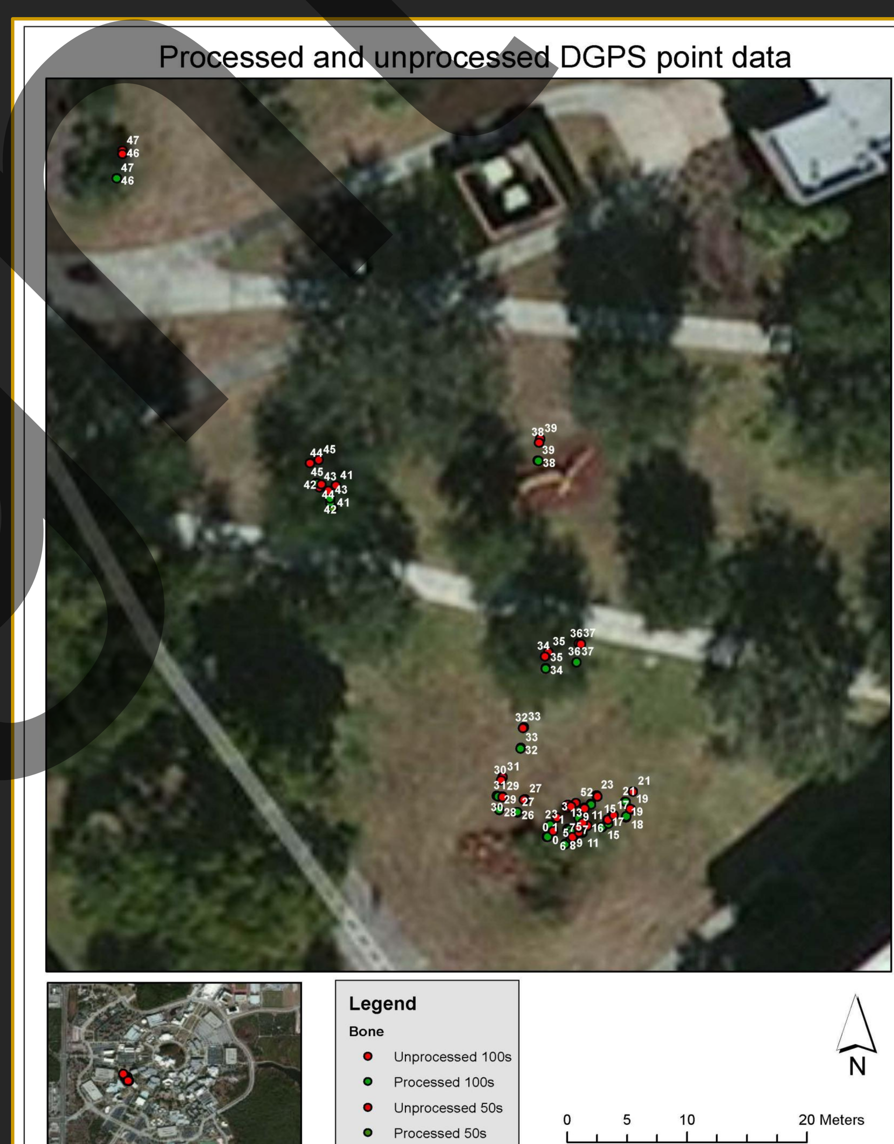

Figure 6: Map of processed and un processed DGPS point data using ArcGIS 10

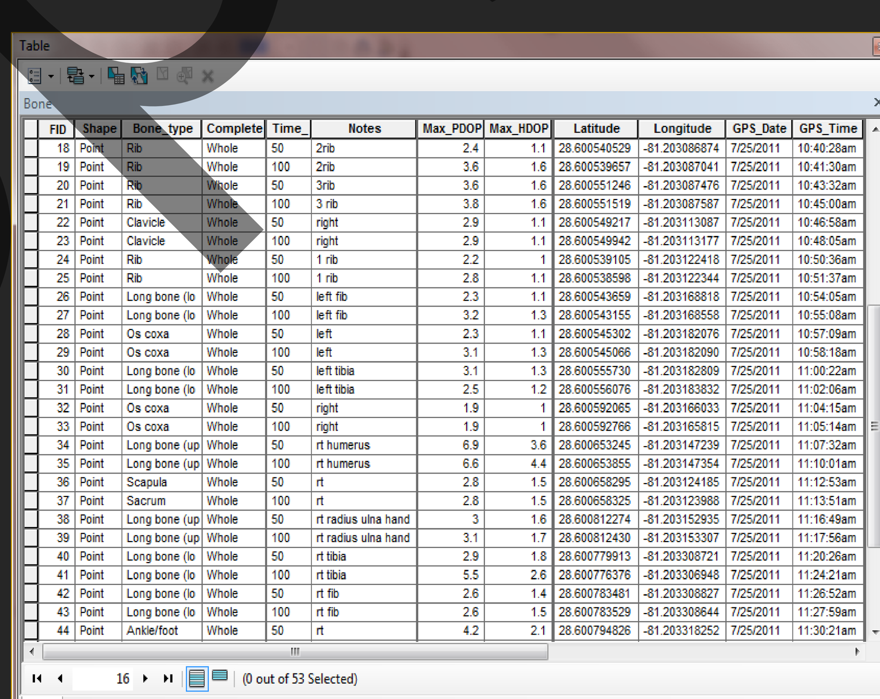

Figure 7: Screenshot of attribute table of DGPS point data in ArcGIS 10

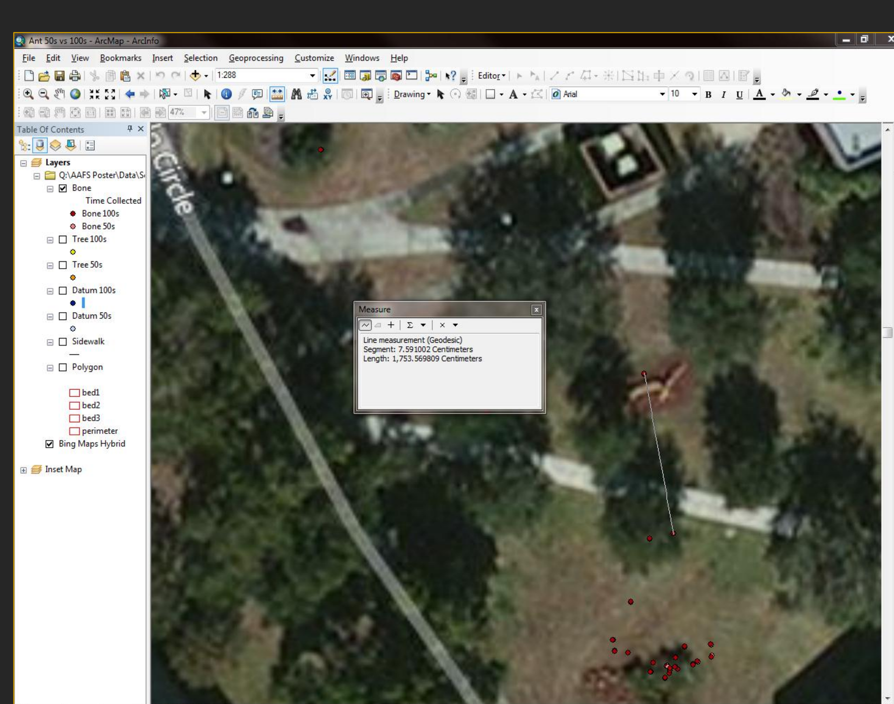

Figure 8: Screenshot of measuring tool in ArcGIS 10 used to measure distance between collected points

RESULTS

After data were differentially processed, the average corrected difference was 126.95 cm for the 50-second collection time and 115.35 cm for the 100-second collection time **(Table 1)**. Areas with tree cover demonstrated a corrected difference of 173.25 cm for the 50-second collection time and 148.56 cm corrected difference for the 100-second collection time **(Table 1)**. Areas without tree cover showed a corrected difference of 113.05 cm for the 50-second collection time and 105.38 cm corrected difference for the 100-second collection time **(Table 1)**.

Analysis of the distance between proximate skeletal elements shows that for both time intervals, the DGPS was more accurate when the skeletal elements were farther apart **(Table 2)**. The 100-second collection time was slightly more accurate than the 50-second collection time for most distance intervals.

Table 1: Distance between processed and unprocessed points for 50- and 100- second collection time

	Time Collected: 50 s	Time Collected: 100 s
	Distance (m)	Distance (m)
Average distance	126.94	115.35
Tree cover average	173.25	148.56
Open area average	113.05	105.39

Table 2: Actual distance and GPS distance for 50- and 100- second collection time

Time collected: 50 s			Time collected: 100 s		
Actual distance (cm)	GPS distance (cm)	Difference (cm)	Actual distance (cm)	GPS distance (cm)	Difference (cm)
10	16.93	6.93	10	16.23	6.23
15	19.26	4.26	15	19.10	4.10
20	23.47	3.47	20	24.05	4.05
25	27.10	**2.10**	25	27.07	**2.07**
30	31.76	**1.76**	30	31.52	**1.52**

DISCUSSION AND CONCLUSIONS

Overall, the most accurate method was using processed data with an average collection time of 100 seconds for both tree cover obstructed and unobstructed areas. However, the 50-second collection time was sufficient in unobstructed areas for mapping a skeletal dispersal. Furthermore, the distance between bones is a consideration when mapping individual bones or clusters. It is recommended to map individual features when bones are at least 25 cm apart, and map clusters of two or more bones that are less than 25 cm apart as one feature.

Generating GIS maps with DGPS data has numerous benefits for mapping skeletal dispersals. Aerial maps are easily added to the mapped scene data as a base layer, and site features such as trees, sidewalks, and structures can be included on the map for scene context. The DGPS software (TerraSync 3.0) also allows recordation of attribute data **(Figure 7)** for features through preset data dictionaries, such as bone type and side that can be accessed in a GIS using an attribute table. Notes may also be included during collection of points which may also be accessed in an attribute table. The user may then label the map with information for presentation or clarification purposes. Furthermore, distance between features can be easily calculated with a measuring tool **(Figure 8)**. This may be useful in a court setting where the distance between bones and scene features can be easily determined while testifying.

The addition of this equipment for mapping scenes involving scattered skeletal remains provides numerous benefits for analysis and presentation of contextual and attribute information. Controlled research using DGPS and GIS for mapping human remains is necessary, as previous research for this application is minimal. Further research is currently being conducted to determine the accuracy of the DGPS receiver used for this project in unobstructed and obstructed environments utilizing different scenarios. This controlled research will demonstrate that the combination of DGPS and GIS is a viable option for analyzing and mapping scenes involving scattered human remains.

ACKNOWLEDGEMENTS

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