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GPS Surveying and On-Site Stone Tool Analysis: Equipping Teams for Landscape Analysis in the Egyptian High Desert

Abstract: The ASPS project is documenting and explaining the distribution of stone tools across a desert pavement landscape. Artifact visibility is high and artifact densities are such that tens of thousands of stone tools must be processed. A computer system was needed that would accept direct GPS and digital caliper input, that was highly portable, that could operate on batteries for an entire day, and that could survive the rigors of the Egyptian desert. We used PocketPC handhelds running ArcPad with customized data entry forms and directly connected to GPS units through a serial connection. On-site stone tool analysis was done with these same handhelds and a self-authored data collection program that communicated with digital calipers through a secondary serial port. In addition to describing this technology, this paper discusses some of the training and organizational solutions that were critical to the successful application of the technology.

Introduction

Over the years, handheld computers have become increasingly powerful and capable of running an ever wider range of applications. This trend has allowed archaeologists to take computers into remote field contexts to collect and process data more efficiently. In survey applications, the two basic needs are recording location and recording the contents of that location. As for the former, the software and hardware solutions for recording GPS points and basic contextual data are well established, and there exist a number of commercial choices. However, in some contexts archaeologists also need to go a bit further and do on-site stone tool analysis. In the case presented here this was primarily because the quantity of material prohibited transport back to a central lab. In other cases, such as in the Australian outback, on-site stone tool analysis is preferred because it addresses cultural sensitivities by leaving the archaeological record essentially undisturbed. However, unlike GPS, here the technology, while not particularly complicated, is not well established at all, and we found ourselves having to put together our own system. Additionally, the scale of what we were doing meant using multiple survey teams which in turn made reliability and training critical issues which we discuss here.

In 2000, we began a multi-year project to survey a portion of the High Desert immediately adjacent to the Nile Valley at Abydos, Egypt (Olszewski et al. 2001, 2005). One of our main goals is to describe the distribution of artifacts across this landscape in order to test models of Middle Paleolithic settlement systems. To do this we have designed a sampling methodology wherein every 100 meters we place a 1 m radius circle on the desert pavement from which we collect and analyze the stone tools. When we encounter high density locations, in addition to placing a 1 m radius circle, we screen all the surface material within it, and analyze all of the stone tools above 8 mm. At the high density locations, notes are also recorded on the kinds of diagnostic materials found on the surface, the total area of the location, etc.

To do this work quickly and efficiently, we have developed a number of computerized systems (McPherron / Dibble 2003) that build on and adapt the systems we have developed elsewhere (McPherron / Dibble 2002). For survey work, there exist a well established set of GPS/GIS solutions. However, for the stone tool analysis, the solution is less clear. Here, the main technological challenge derived from the fact that we wanted to do nearly all of the analysis on the high desert itself rather than in a lab. The high desert in our survey area is incredibly rich. Overall, in six weeks of work, we have recorded nearly 30,000 stone artifacts. It was clear early on that from a practical point of view it was going to be very difficult to collect this material and transport it back to a lab each day. Aside from the overall quantity, some areas are also incredibly dense. There are collection units with over 1000 artifacts. Thus we needed a system that would allow us to quickly and efficiently work through a large collection of stone tools while seated on the desert pavement. Though we considered dropping it, in the end we decided too that we had to record length on a portion of the artifacts. Thus, this meant developing a system that supported digital calipers and preferably direct transfer of caliper measurements to a computer program. Lastly, we knew that we would need to have up to four survey teams working simultaneously. Thus, whatever solution we applied, we would have to purchase five times – one for each survey team and one backup of each piece of equipment. This placed a serious limit on how much we could spend on the system's components, and it made reliability and training important issues.

Hardware

We needed the technology to be easily accessible with a laptop, a database or data entry program, and a set of USB or serial calipers. However, the weight, fragility, cost and limited battery life of laptops, combined with the difficulty of reading them in full sunlight, made this solution impossible, so instead we designed a system around HP iPAQ handheld computers *(Figs. 1, 2)*. The model we chose (the HX4700) has a built in serial port, a CF memory card slot that can be used for storage, an SD memory card slot that can be used as an additional serial port, and interchangeable batteries. The latter seemed like an essential feature as we expected that the iPAQs would not last an entire day on a single charge. In fact, by turning off the screen's backlight we were easily able to use them for an entire day with battery life to spare. In bright sunlight the backlight makes absolutely no difference to the readability of the screens. As for the serial ports, we needed to be able to connect both a GPS unit and calipers. As it turned out, we may have been able to use just one serial port as it was not necessary to run both the GIS application and lithic analysis application at the same time. Thus we could have first recorded a GPS point, disconnected the GPS, connected the calipers and recorded the lithics. However, the two serial port solution allowed us to leave cables connected (which reduces wear and tear on the connectors), and we have found the iPAQ's built in serial port more difficult to program. Thus we used an SD to serial port adapter manufactured by Socket. The CF card slot was used for a 512 Mb memory card.

Fig. 1. Each team's equipment. From top, clockwise, SmartCable SPC to serial interface, Mitutoyo digital calipers, Garmin GPS, GPS charging and communications cable, HP iPAQ, Canon digital camera, Navcom RT-250 radio, Socket serial to CF card adapter, and a memory card.

All of the GIS layers and the lithic databases were stored here. This is important because if the battery in the iPAQ is completely drained, all data stored in its memory will be lost. Normally, because a charge lasts an entire day and because we transfer the data each day, this should not be a problem. However, we run an especially great risk because we disable the automatic power off feature of the iPAQs (the option that normally puts them to sleep after a few minutes of inactivity). We do this because if they power off on their own, it can crash the GIS and lithic data collection software when they are restarted. This is because these programs do not respond well to having their connection to the serial port stopped and restarted (by powering off and then back on) while the programs are running. Unfortunately, the iPAQs automatically power on when a memory card is removed and this can happen by accident while the unit is stored in a bag. Thus, although it is not frequent that the contents of the computer are lost, it happens often enough that data cannot be stored safely in the internal memory. For this reason, it is extremely important to have all of the software needed to completely reinitialize these computers on hand in the field.

Though they look somewhat fragile and though they have any number of slots, buttons and connectors where sand can enter, we have found the iPAQ units to be surprisingly solid. Nevertheless, we purchased protective metal cases for each unit *(Fig. 1)*.

These cases have a lid that snaps closed and cut-outs for connecting cables. So while they do not provide so much protection against sand, they do provide protection against shock and against direct sunlight. As a result, of five units purchased three years ago, all five are still in perfect working order after several seasons in France, one season in Ethiopia, and one season in Egypt.

Connecting calipers to the iPAQs was the most difficult technological hurdle. Whereas serial calipers can be connected to the iPAQ easily using the SD to serial port converter mentioned above, non-serial calipers require a more complex solution. In our case, we owned a number of Mitutoyo calipers with the SPC to USB interface. This interface is, literally, a black box that takes input through one cable from the calipers and then outputs through another cable to a USB connection on a PC. The output format makes it look like a USB keyboard is attached to the PC and, therefore, the calipers can be used with any software without a special driver. However, USB ports do not exist on the iPAQ 4700 and are still not common on many handheld computers. So, we purchased a SmartCable interface box that accepted caliper format data and cables (the format is called SPC) and output serial data. This was a rather difficult piece of equipment to find but it worked quite well and required no batteries.

For our GPS units we used Garmin GPS 60s. Our main concern here was simply to find a rugged GPS unit with good battery life. We were not interested in color screens or the ability to upload maps since our iPAQs served that function. To connect the GPS unit to the iPAQ we used another set of specially designed cables. These cables have at one end a connection compatible with the round, 4-pin connector on the Garmin GPS 60 units and at the other end a connector compatible with the built-in iPAQ serial connection. In addition, these cables have a power connector that allows a 12 volt connection to recharge the iPAQs. Thus we used an additional cable that had at one end a 12 volt male cigarette lighter connector to connect to the GPS to iPAQ communication cable to charge the iPAQs from car batteries at night.

In addition to this equipment, each team carried a digital camera and a walkie-talkie. For the digital camera, our main concern was battery power. We settled on an inexpensive model that used AA batteries. The only problem we had was that the automatically retracting lens cover stopped fully retracting after a little more than 1 day in Egypt (even Cairo was too much for this model). Fortunately, the lens cover could be fully opened by hand. For the walkie-talkie, the problem was finding units with high enough power ratings that they can be used over large distances. In the United States, the FCC limits the power of non-licensed radios to 0.5 watts. Similarly, the Egyptian government limits the power of radios that can be imported. While previously we had tried some Motorola walkie-talkies that use AA batteries, this time we tried some French marine radios that are quite rugged (equipment designed to resist water is also well designed to resist sand). Though the batteries were easily charged using 12 volt batteries at camp, unfortunately on this particular model the batteries are not easily interchangeable and did not generally last the entire day. Though all four radios were purchased new, some had batteries which lasted significantly longer than others.

Fig. 2. Two person data entry. One person (left) is dictating stone tool attributes and taking measurements while the second person moves through the E-CE data entry program and makes the appropriate menu selections. Measurements are transferred directly.

Software

To collect spatial data we used ESRI's ArcPad application. This program is a simplified version of the older ArcView software or the newer ArcMap program. It has limited functionality but it can (a) display ESRI raster and vector layers, (b) take input from any GPS device that supports NMEA format and (c) allow these GPS points to be added to point layers with associated attribute data. It is possible to use ArcPad without the other ESRI GIS products so long as the PC GIS is able to read ESRI format layer files. In our case, however, we used ArcMap to manage the background layers that were also placed on the iPAQs and to manage the new data generated each day. Although it is possible to associate attribute data with each GPS point using only ArcPad, we used ESRI's Application Builder for ArcPad to design custom data entry screens. These data entry screens used pull-down menus to limit choices and structure input. We also wrote VBA code in the Application Builder to automatically fill certain fields (for instance the date) and to read the existing database and automatically provide the next available ID number for each new point. In this way we could control the numbering of our sites and samples and avoid mistakes that come from skipping and repeating numbers. Additionally, the Application Builder allows certain fields to be specified as mandatory. Overall, this software solution for the GPS data was quite effective. With more time we likely could have developed an application that would have allowed us to also enter the lithic analysis data into this same application. The main downside to the ESRI software is its cost. Without an educational discount, the solution described in this paragraph costs approximately $ 5000 plus an additional $ 500 for each iPAQ.

For the lithic analysis, the main challenge was finding a program that works with calipers connected to the iPAQ. iPAQs (at least when our purchases were made) do not support the USB interface. So, whereas on a PC calipers can easily be used with any application via a USB keyboard wedge interface, on the iPAQ we were obliged to find a solution that would work with the older serial interface. We know of no software for the PocketPC that does this and, as just stated, we suspect that the easiest solution for most users would be to develop code in the Application Builder VBA environment. However, rather than do this, because we had already written a VisualBasic application for Windows to do lithic data entry, we ported this program to the PocketPC system using Microsoft's Embedded Visual Basic 3.0. While not as difficult as writing a program from scratch, reformatting the program to work on a much smaller screen and recoding a program to work in Embedded VisualBasic took considerable effort. The result was a program called E-CE (CE is an earlier name for the PocketPC operating system) which is available with source code on our web site (http://www.oldstoneage.com/). The essential features of this software are that it (a) communicates with the calipers across a serial interface and therefore makes taking measurements fast and accurate, (b) provides user defined fields and menus to make data entry quicker and reduce errors, (c) allows for conditional data entry, making it possible to skip unnecessarily fields where appropriate and (d) provides large buttons for numeric input, again to speed-up entry and reduce errors.

Training and Organization

Aside from the problems listed above, the system worked very well. In a short period of time we were able to record hundreds of localities and tens of thousands of lithics. Additionally, not one working day was lost due to equipment failures. In part the success of the project lay in the hardware and software solutions just described. However, the key to the success of the project was training. Training in archaeological contexts is often absent to minimal, and can be very ad hoc and informal. When dealing with computer technology, and particularly technology that is somewhat difficult to use, fragile, and mission-critical like ours, it is best to take a very pro-active and rigorous approach. What we did was divide our team into four groups. Each group was given a letter (we used alpha, beta, gamma and delta). All of their equipment, including cables, chargers, batteries, and so forth, was so labeled. We then gave an introduction to the entire crew as a group. Next, the crew broke into their teams and from the dig house went out and did "actual" surveys. By actual we mean that every effort was made to recreate a real survey situation without taking shortcuts. Thus the equipment was fully stored in the equipment belts prior to setting out, measurements were taken on artifacts (even if they weren't stone tools), locations were recorded with the GPS units, etc. This was done intensively over the course of an afternoon and then again for part of the next day. As a result, a number of glitches in the hardware and software were discovered and corrected. Though the training sessions cost us 10% of our survey time, without this training, more days would have been lost in the field while we solved hardware and software problems.

Next, in the field, since forgetting one cable or one set of batteries could mean most of a day lost, we designated one person from each team to handle the computer equipment. It was their responsibility each morning to collect the equipment from the chargers, verify that nothing was missing, that backup batteries were present, etc. The first few mornings a check list was used to help train each person what to look for. At the end of the day, that person was also responsible for placing the batteries in the chargers, their radio in a charger, and their computer on a charger.

Labeling equipment by team had other advantages as well. It meant that the same equipment was used by each person each day and the "temperament", if you will, of each piece of equipment could be learned. Additionally, by labeling each piece we could more easily identify equipment that was failing. So, for instance, we quickly learned that some team's radios would work longer on the same charge than other teams and, therefore, it caused less concern when towards the end of the day that team could not be reached by radio.

Conclusions

There were three weak points in the system. First, as already mentioned, the camera lens covers failed almost immediately. Though annoying, this was not serious since we had expected to lose some cameras as a result of this work. This is one reason why we purchased inexpensive cameras. Second, several of the cables in this system are delicate and prone to breakage. In particular, the SD card to serial port cable proved very fragile, as did the 4-pin GPS connector on the GPS to iPAQ cable. With all the cables and connections, it is quite easy to, for instance, walk away with the iPAQ in hand and forget that the GPS unit is still connected and on a belt. The result is that the cable is yanked and the connections broken. We lost one cable this way. Third, the radios we used to communicate between teams, while quite solidly built and fairly powerful, did not last an entire day and had battery units that could not easily be swapped. Radios that use AA batteries would have been better.

It seems clear that given current trends in computer technology, there will be more options in the future for highly portable computers and it is likely that they will include all the current connections (e.g. USB) and software platforms (e.g. Windows rather than Mobile Windows). Hopefully these computers will last at least one day on battery power, but the trend has been to add computing power at the expense of battery life (we used to use inexpensive, hand-held DOS computers (HP-100) that would run for days on a pair of AA batteries). For now, hand-held computers like the HP iPAQ seem to offer the best solution.

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