A Field Computer for Animal Trackers

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ABSTRACT

The field computer system has been developed to gather complex data on animal behaviour that is observed by expert animal trackers. The system is location aware using the satellite Global Positioning System. The system has been designed to empower semi-literate trackers. User testing showed that trackers were easily able to master the interface. They benefit from greater recognition, while the wider community gains from access to the knowledge of the trackers on animal behaviour.

Keywords

User Interface, Empowerment, Location Aware, Context Aware, CyberTracker

INTRODUCTION

Expert animal trackers play an important role in providing information on the distribution and behaviour of animals, which is overlooked by current surveillance techniques. The best trackers, however, are found in hunter-gatherer communities with oral traditions and who cannot read or write.

We have developed a field computer with a graphical user interface that enables trackers to record their observations. A pen-based handheld computer system for observations, and satellite Global Positioning System (GPS) receiver to obtain position data, constitute the field data collection system, while a base station PC system serves for long-term data storage and visualisation.

Our novel computer system has enabled functionally illiterate trackers to communicate their expertise to the research community. The initial system ran on an Apple Newton and it now runs on Palm handhelds and compatibles.

Our system was initially developed from February 1996 and tested in the Karoo National Park in June and September/October 1996. It has been continually refined and updated since. The system has subsequently become a successful product [1] with a number of applications. The system has consistently attracted media attention over the years [5,8,14,16]. While the use of the system has been described in its field of application [7,8] the design criteria and design methodology have never been published.

Contribution

We developed a user interface for functionally illiterate users. The interface is adaptable for varying educational, cultural and language backgrounds.

Trackers are experts in their own right and have access to very sophisticated and complex information about the environment. This knowledge is not available to the wider community, mainly because of the barrier of illiteracy[1]. Our first *hypothesis* was that trackers are very familiar with the way signs point to meaning and so should have no trouble in attaching meaning to the icons of a well designed graphical user interface. We *further hypothesized* that such an interface will give the wider community the benefit of the knowledge of the expert trackers. Finally *we believed* that such a system would empower the trackers and allow them greater recognition and rewards for their skills.

The system was developed as a *critical action research* project and it has gone through a number of cycles. The trackers participated in an iterative design process and themselves validated each aspect of the interface. The success of the intervention can be judged by the impact on the users who have been recognized as experts in their field [7,8].

CONTEXT AWARE COMPUTING

A similar independent project was initiated under the banner of "Context Aware" computing by Pascoe *et al.* [11] shortly after our first field trails. The notion of

[1] Although it is questionable if written note taking could cope with the observation volumes and the need to process the results for scientific presentation and querying.

Context Awareness is due to Schilit et al. [14] and relates to the ability of a computer system to sense and react to its environment. Pascoe *et al.* began by employing a slightly different notion of context awareness, namely that the user annotates records that are automatically sensed. The annotations are then attached to the context. They found, however, that the distinction between context and its annotation (the so-called e-note) was artificial when used in field observation systems since field observations are largely about establishing the complex context of the observed behaviours. They thus end up "eliminating the distinction between context and content" [5, p 422]. This leads on to our critique of "context aware" computing below.

TRACKERS IN SCIENTIFIC RESEARCH

Tracking involves the recognition and interpretation of natural signs. To make sense of these signs the tracker creates hypothetical models of animal behaviour that explains underlying causal connections between signs.

Expert animal trackers interpret and derive their knowledge from direct observations of animals. To interpret spoor (tracks and signs) the tracker must have a sophisticated understanding of animal behaviour and they develop this expertise in a life of learning in the wild. Trackers obtain much information that would otherwise remain unknown, especially on the behaviour of rare or nocturnal animals that are not often seen.

In the past trackers have assisted in research on animal behaviour, but received little or no recognition for their contributions. Recently some researchers have recognised the contributions of trackers, in particular, Stander *et al* [16] quantified the accuracy and reliability of trackers in scientific research. In a test for accuracy, the Ju/'Hoan San team was correct in most (98% of 569) spoor reconstructions. Most significant of these were the correct identification of individually known animals and the reconstruction of complex behaviour from spoor.

While trackers have worked in collaboration with researchers, it has still not been possible for trackers to gather data independently. A major obstacle has been that the best traditional trackers often cannot read or write. However, illiteracy is not the same as an inability to associate an artificial symbol with a non-visual entity or an abstract concept. Trackers can associate a natural sign with the abstract entity it represents: the past behaviour of an animal which is not directly observable [6].

DESIGN OF THE FIELD COMPUTER

Our design decision was to focus on creating a system that would empower trackers. We rejected the idea of a fully "context aware" computing system that could replace trackers. The field computer was designed not to replace human skills but to make these skills more valuable.

Location awareness was built into the system to assist the users. A base station collated observations and presented them to managers and scientists.

A Critique of "Context Aware" Computing

Our critique of "context awareness" has two aspects:

1. context awareness is an inappropriate metaphor in the design of field computers, since it leads to an over - emphasis on automatic sensing;
2. if automatic sensing of the environment is removed from the notion of context awareness one is left with location awareness in time and space, which can be seen as a useful adjunct to field computer.

We believe that for our application, namely field observations, the notion of "context awareness" is unlikely to lead to the right kind of device or interface. The very task of field observation is *itself* context sensing.

We believe that the distinction we wish to make is best understood when taken to extreme. "Context Aware" taken to the extreme becomes "Sentient Computing" [1], where "applications appear to share the user's perception of the environment". In the context of field work, context aware in this extreme form would imply a computer that is able to make field work observations itself!

We offer our initial design decisions as an example. When considering the design of a device to record spoor, our collaborator, Mr. Louis Liebenberg, originally proposed just such a "context aware" technology for automatic spoor identification in the wild by employing photo-grammetric techniques. Rhino and Elephant leave tracks that are as individual as fingerprints and it was thought that imaging technology might lead to the automatic identification of individual animals. The feasibility of such approaches, initially for large cats, were investigated by a team under Professor H. Rüther at the University of Cape Town but abandoned as too complex (personal communication).

In the first cycle of design, Mr Liebenberg was persuaded that computers are better able to assist and empower users and enable them to extend their abilities. This was much more in accord with his other activities in training and gaining recognition for the highly skilled but semi-literate animal trackers in Southern Africa [6].

Thus "context awareness" taken to the extreme is inappropriate for field computers. A much more powerful design criterion is the traditional one of *empowerment of users*. Our requirement is thus merely one of *location aware* computing, where location is taken to be position in both space and time. The field computer system should not attempt to do what trackers can do, such as their ability to recognise and interpret very subtle signs in nature. Rather, the highly refined skills of the tracker should be recognised and the computer should enhance these skills and not attempt to replace them.

Design of user interface

As noted above, trackers are expert interpreters of signs. This ability can be exploited in the design of a user interface.

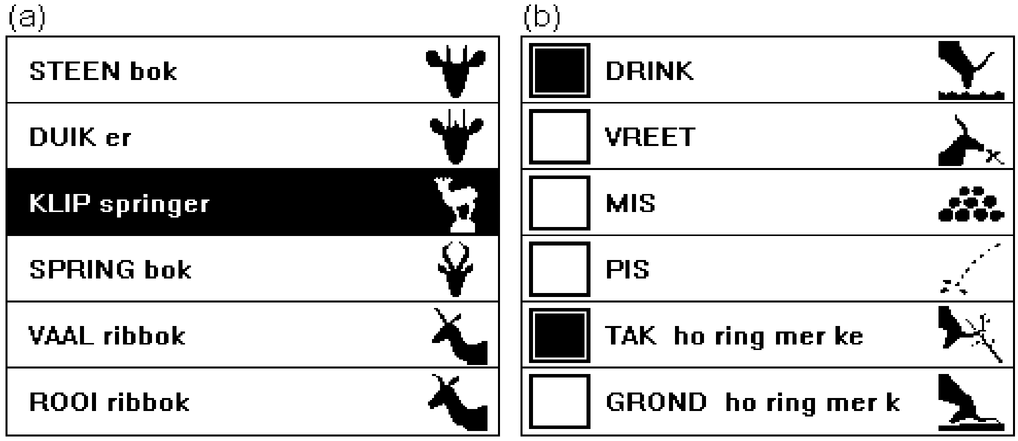

Figure 1. The layouts of two types of screen available for data input showing some of the icon: (a) Single-selection item list for displaying several mutually-exclusive options, such as species. (b) Multiple-selection item list for displaying options which can occur simultaneously, such as activities.

The computer user interface consists of artificial signs (icons) which the tracker must recognise, select and connect with each other by navigating a path through a sequence of screens. The meaning of artificial signs corresponds with the tracker's interpretation of natural signs (animal tracks). The tracker therefore connects a sequence of artificial signs corresponding with a sequence of natural signs.

In our iterative design methodology (or action research method) the trackers were consulted at every stage of development on both the visual layout and the behaviour of the system. Their input was incorporated into subsequent designs, and they could witness their input being immediately acknowledged. The interface includes text where appropriate as requested by the user's themselves. The level of literacy varies from illiterate to limited secondary schooling. The words of the current interface were broken up into readable syllables. The emphasised syllables are in capitals to assist in the identification of the word, see Figure 1.

The interface includes provision for simple error correction. No hidden menus or "pop-up" interface elements were included in the design.

THE FIELD COMPUTER SYSTEM

The field computer enables trackers to record all significant observations they make in the field. Visualisation on the base station makes it possible for scientists to have instant access to all the information gathered over a period of time.

The field computer is designed to be quick and easy to use in the field, even by trackers who cannot read or write. Trackers can therefore collect a large amount of data during the course of their normal monitoring with very little effort. In addition to direct observations of animals, trackers can also collect information based on animal tracks and signs. The field computer therefore makes it possible to generate a large quantity of very detailed data.

Icons allow the tracker to select options by simply touching the screen a pen-based computer. The tracker goes through a sequence of screens until all the necessary information is recorded. When the tracker saves the information a date/time stamp is added and an integrated Global Positioning System (GPS) automatically records the location of observations.

The menu includes icons that enable the tracker to record sightings of animals, spoor observations, species, individual animal (such as individual rhinos), numbers of males, female and juveniles. Species covered may include a full range of mammals, birds, reptiles and other animals. Activities such as drinking, feeding, territorial marking, running, fighting, mating, sleeping, etc. can be recorded. A plant list enables the tracker to record plant species eaten by the animal.

With each recording the tracker also has the option to make a field note if he observes something unusual that is not covered by the standard menu. (An illiterate tracker can ask a literate apprentice tracker to write in the field notes).

When the tracker gets back to the base camp he follows a very simple procedure to transfer the data onto the base station PC.

System Requirements

The system is designed to hold up to 1 week's data safely, in the event of unexpected long trips away from the base system. Based on the data gathered on the field tests, we estimate that it is possible to make 300 observations per day, which translates to roughly 100K of data per day

Similarly, battery life should preferably allow eight hours of gathering without needing to be changed. Rechargeable batteries are therefore not useable.

BASE STATION

The base station program is primarily a database to store the data gathered by the field system. It is not the focus of this paper but two features are relevant: the interface designer and visualization capability.

Interface designer

The system will need to adapt to changing requirements. For example, new species may be added, or a higher level of detail may be required for a particular species of current research interest.

This requirement was met via a simulated interface on the base station where the actual data collection screens could be designed.

This feature was used during testing to allow iterative refinement of the interface and icons.

Visualisation of Data

A simple query system allows the user to display observations for any selected period on a map (see Figure 2). The user may query any level of detail corresponding to the information gathered by the trackers. The data is also quantified in the form of graphs and in a spreadsheet format. Standard statistical methods can be applied to analyse the data.

The field computer system not only enables trackers to communicate all their observations to the conservation manager on a day-to-day basis, but also stores the information over time long after the trackers may have forgotten the specific details. Long term ecological trends can therefore be monitored in much more detail than was possible before.

Initial	**Schooling**	**Literacy skills**
KB	none	Functionally illiterate
CB	Std 7 (Grade 9)	Functionally literate
JM	Std 2 (Grade 4)	Functionally illiterate

Table 1 Educational backgrounds of the trackers involved in the project, including their schooling, literacy and tracker training details.

RESULTS FROM USING THE FIELD COMPUTER SYSTEM

Three trackers, Karel Bernadie, Chocolate Bosch and James Minye, tested the system initially (in three field trips to the Karoo National Park in June, September and October 1996), and two, Karel Benadie and James Minye, have extensively tested the field computer system for over three years in the Karoo National Park. The biographical details of the trackers who participated in the field tests given in Table 1.

In June, a series of 24 structured tests were run to investigate and refine the initial design in collaboration with the trackers. These are referred to as the design tests. The number of users and tests is in accordance with the findings of Nielsen and Landauer [9], which are applicable in this case with a constrained task in a circumscribed domain and expert users.

Subsequent collaborations were conducted as actual field trials (September and October). The initial system was developed on an Apple Newton (Figure 3). The system was then ported to a PalmPilot and slightly adapted for the smaller screen (Figure 4). The production use of the system in the Karoo Park extended over the following 3 years.

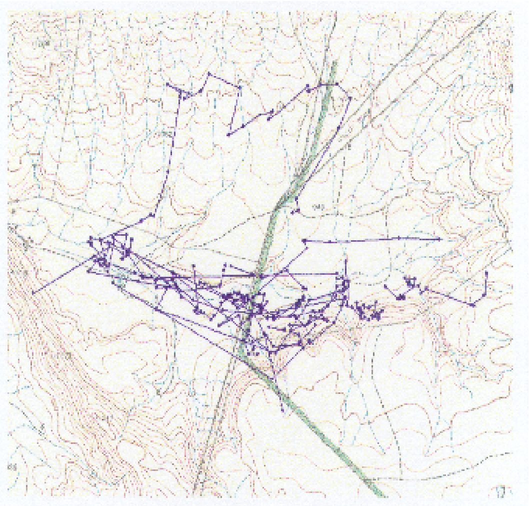

Figure 2. Visualization of the map of the Karoo Reserve, with the query on all the Rhino sightings during the second field test

Figure 3: The original Apple Newton System in use in the field.

Figure 4: The PalmPilot version of the Field Computer. in the field.

Text and Icon Recognition

In the design tests (June), CB encountered a few minor problems, which were primarily due to the use of words and animal names that were unfamiliar to the trackers. Both trackers were consulted as to which words they were familiar with and the text was altered accordingly. KB found some difficulty with the identification of some species, such as the antelope, due to them being too similar. For example, the duiker and the steenbok have very similar body shape and size. However, this was largely due to the difficulty of identifying an exact species from the limited information presented in a small icon, especially considering the vast number of species and the slight differences between them.

The separation of the Afrikaans words into syllables with spaces between them did simplify the reading process, since it imitated the literacy development process. The capitalisation on the syllables of emphasis did not appear to make any difference in assisting the tracker to read the word. It is not clear whether or not such separations can be used for all languages. In the case of English, where the spelling rarely imitates the sounding of the word, it is unlikely that this break-up will assist in word recognition.

The presence of the icons speeded up subsequent recognition of the words considerably. Once it was understood that both the icons and the text can be used to identify the animal or activity being presented, the identification process ran smoothly. Some omissions in the lists were pointed out by the trackers and these were subsequently added. For example, the breaking of branches by the mother rhino to allow the calf to reach the newer leaf-buds at the top was omitted and this was pointed out by KB in the first test of interface elements.

The following points regarding icon recognition and suitability were observed:

- The users found the identification of the icons representing activities to be easier than those representing animals. This seems to be contrary to the view that static icons are better suited to names than actions (see [12], p 117).
- The use of some universality was acceptable in representing concepts. For example, the use of a depiction of a rhino feeding to represent the concept of any animal feeding was not limiting and thus the same icon could be used throughout the interface.
- In identifying an animal from an icon, more attention is paid to the overall shape of the animal, rather than to details within the shape. For example, the zebra icon was expected to be easy to identify, since it clearly illustrated the most striking feature (to the designers) of the animal: its stripes. However, the trackers found the greatest difficulty with identifying this icon, since the overall shape of the animal appeared to be that of a dog rather than that of a horse.
- The accuracy of identification improved remarkably from the initial presentation of the words to the second and third presentations. KB scored 100% accuracy on all tests following the second. Those words which had been difficult to read previously, owing to their being long and unfamiliar (such as ‘bakoorjakkals’, ‘silwerjakkals’), were identified with little difficulty on the second and third trials and almost immediately on all subsequent trials. Once the words had been understood, the user no longer needed the spacing between syllables to identify the animal signified by the text.

In the final tests (October) the trackers found the identification of the animals through icons alone to be simpler than through interpreting the text. This was demonstrated by the speed of recognition of the icons by the functionally illiterate tracker in the first introduction to the interface elements. However, since icons can be ambiguous, the concurrent display of the word is helpful as a secondary visual cue for identification.

Moving between screens and selecting single items

The classification system used in the interface was found to be less useful than expected in assisting the trackers in finding the relevant animal in a list or set of sequential screens. The trackers appeared to make more use of the position of the animal in the lists than of their position in a hierarchical classification of animals, e.g., hooves (large or small) versus pads (with claws or without). Thus certain intermediate screens which would have resulted in a reduction of the number of animals to be paged through in the final list, were removed in favour of longer lists [2].

The trackers were asked whether the hierarchy of small and large pads was appropriate for their use. They replied that the concept was not familiar to them, although they were confident of being able to use whichever classification was given to them. This was borne out by their successful use of the original classification system. However, they preferred to locate elements in a mixed list, using the exact positions of each item to assist them in subsequent searches. Thus these expert users learnt the symbols and then employed an *identity mapping* [10].

The subjects encountered no difficulty with the concept of

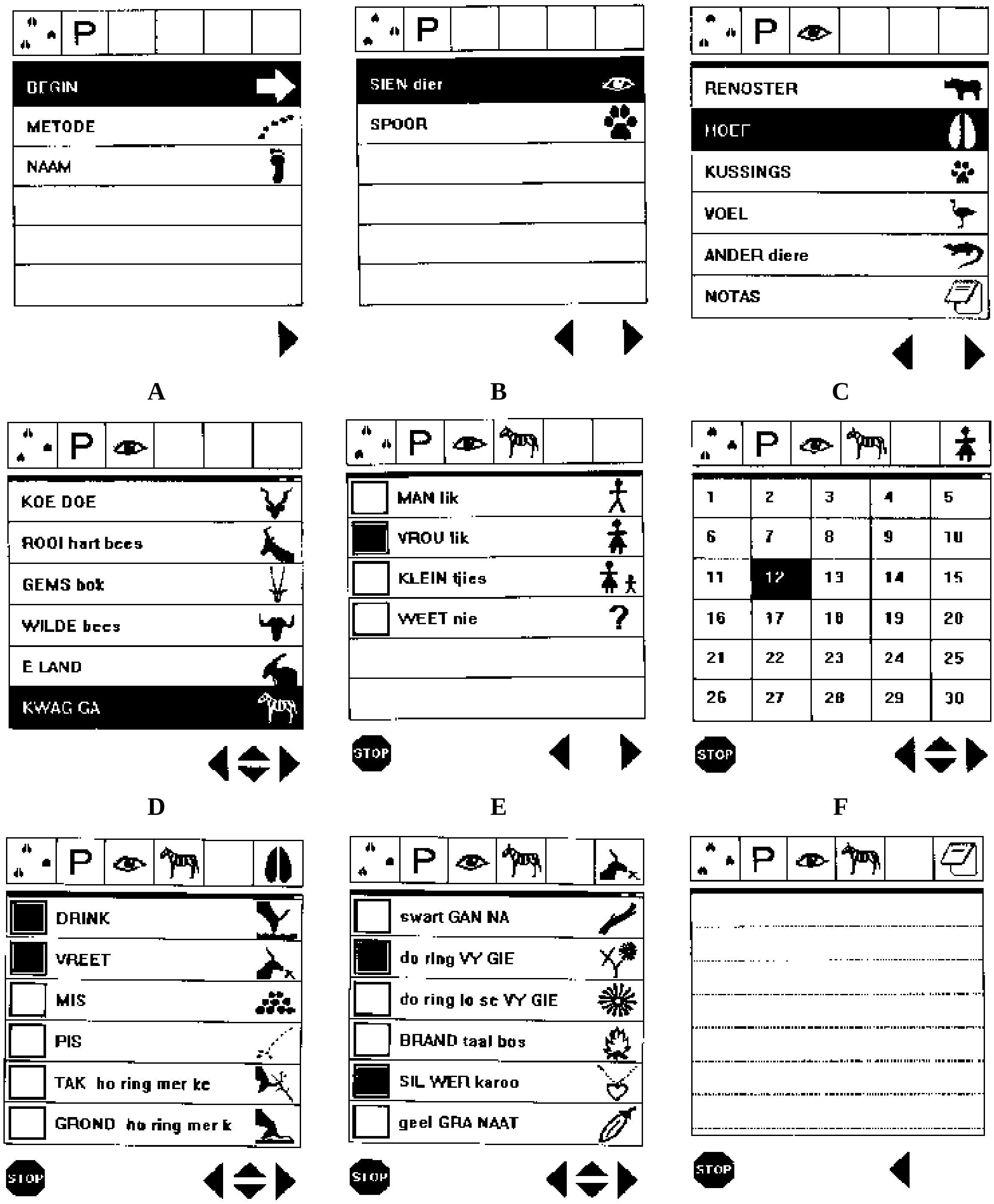

Figure 5: An Entry Sequence: Introductory Screen has been completed and tracking mode and tracker name selected. The icons at the very top of the screen are a visual reminder of the current status. The user selects “begin” (A) and indicates (B) that this is an actual sighting. The type of animal is selected (C). (D-E) The observation concerns Zebra Females, 12 in number (F). Since drinking and feeding (G) were the actions, the type of plant consumed is added (H). Finally a note can be added and the interaction terminated (I).

touching an item on the screen and eliciting a response. It required little explanation to enable them to move between screens and to page up and down through lists with ease (see Figure 5 for an example capture sequence).

The separate functioning of the *Stop*, *Previous* and *Next* buttons did not create any confusion, providing their use was consistent throughout the interface. Since the Previous button is primarily used for undoing mistakes made either on the current screen or on previous screens, the use of this button for any other navigation through the system did confuse the trackers. The abstract concept of navigation through a interface that was visible one screen at a time, was easily understood by both trackers.

Multiple selection

The concept of a checkbox was also one that required little explanation for effective use. It was also not found to be confusing that more than one item could be selected on those screens containing checkboxes, whereas on all previous screens, only one item could be selected at a time.

Special Spatial Conceptualisation Abilities

The trackers ability to remember the *exact* position of an animal's icon in the interface enabled them to locate the animal they wished to record very quickly. They seemed to maintain a representation of the entire interface in their minds. The trackers were able to distinguish between identical icons, based on position in a list. For example, the brown hyena and the aardwolf, which have identical icons, were correctly identified and differentiated.

Interactive icon definition

The refinement of icons was performed to the satisfaction of the trackers. It was discovered that relatively minor and subtle changes could be made to similar icons to distinguish them from each other, for them to be recognisable as distinct species. The mongoose species are a good example. There are five species, the distinguishing characteristics and icons are given in Table 2. The icons for these were modified so as to exaggerate these characteristics, thereby making them more distinguishable.

Production Use

Although they may not read or write, the trackers have been using the system to record their observations in the field and download the data onto the base station PC. The field computer system captures their ability to interpret signs and yields information on animal behaviour and ecosystems not previously available. The data they collect are very detailed .

The feeding behaviour of Black Rhino, *Diceros bicornis*, was recorded. It showed how feeding patterns shift from the end of the rainy season (January) to the beginning of the next rainy season (September) as plants dry out and mainly succulent species are available [8]. In addition they recorded spoor of rare or nocturnal species that are not normally monitored.

Icon	Common Name	Distinguishing Characteristics
	Small grey mongoose	Basic shape (no distinguishing features)
	White-tailed mongoose	The tip of the tail is white
	Straight-tailed mongoose	The tail is usually held stiffly upright
	Stink mongoose	Has white stripes down the side of its body
	Water mongoose	Often found near water

Table 2. The distinguishing characteristics of the five mongoose species found in the Karoo region, and the corresponding icons which were adapted from the basic shape (small grey mongoose).

Initial field tests indicate that a tracker can generate more than 100 observations in one day, with peaks of 266 observations in one day, and 473 observations over a three-day period. Subsequent experience has indicated that the number of observations vary depending on several factors, not least of which being the physical environment (weather, temperature, terrain), GPS acquisition time and the kinds of information being gathered. Some data require many sightings to be made within a reasonably small area (e.g., kill site analysis) while others (like tracking Rhinos) takes the trackers over large distances. Numbers vary from ~300 observations over 30km in one day to several thousand in a 4 day period.

One computer could generate more than 20 000 observations in a year. If, for example, a large park like the Kruger National Park had about 100 field computers, it could generate more than two million observations per year.

Social Benefits

We found that the field computer gives prestige to trackers who were previously held in low esteem and employed as unskilled labourers. They found an incentive to refine their skills and it made their work in the field more meaningful. Creating employment opportunities for trackers provides economic benefits and will also help to retain traditional skills, which may otherwise be lost. Communities are able to make a unique contribution to conservation and this creates a sense of cultural ownership of conservation.

In the longer term, that is in the last five years, the most measurable benefit for the trackers has been a steady improvement and refinement of their tracking skills. By having options to enter very detailed and specific information, the interface acts as 'learning assistant'. Anecdotally we have had comments such as "everybody thought X was stupid, but now that we see how he's using the computer we realize how smart he is". So social standing was improved.

CONCLUSION

Technology can be developed to enhance human skills in a way that have social and environmental benefits. Rather than consider how technology can become context aware we preferred to consider how computers can assist the awareness of humans.

Over tens of thousands years hunter-gatherers developed a highly refined perception of nature through the interpretation of signs. At a time when traditional hunting is dying out, the field computer system helps to revitalise the art of tracking and develop it into a new science with far-reaching implications for the conservation of biodiversity.

We have shown that trackers are well able to use icons and other elements of a graphical user interface. This verifies our first hypothesis.

The system has proven to be enormously useful and has had considerable impact. It has been used in four African National Parks: Karoo National Park and Kruger National Park in South Africa, and the Odzala National Park, Congo. It has also been adapted to record observations on the Cape Floral Kingdom for Cape Nature Conservation (see [4] under "Projects"). In the USA it has been adopted for tracker training [3].

The first evidence of wider appreciation of the expertise of trackers is apparent from the publications based on their work as well as the exposure on the World Wide Web of the CyberTracker product. We have clearly shown that our system empowers trackers and does not deprive them of their roles.

The original Newton Design and separate GPS system has become an integrated system on PalmOs machines. The initial interface design has stood the test of many years of use very well and remains essentially unchanged. The hardware has developed in the past years and is now smaller and much faster (see Figure 6) and GPS is now much more accurate. The software has been released as free software under a "Greenware" licence.

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Figure 6. The latest hardware for the Field Computer: Handspring's Visor. Attached to the expansion port is the Magellan GPS Companion, a 12-channel global positioning system receiver.

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