Integrating Traditional Knowledge with Computer Science for the Conservation of Biodiversity

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ABSTRACT

The art of tracking, as practised by San hunter-gatherers of the Kalahari, may well be the origin of science. Trackers gain a detailed understanding of animal behaviour through the interpretation of tracks and signs. In this way much information can be obtained that would otherwise remain unknown, especially on the behaviour of rare and nocturnal species that are not often seen. The best trackers, however, are found in hunter-gatherer communities with oral traditions and cannot read or write. The authors have developed a hand-held field computer with a user interface that enables trackers who cannot read or write to record all their observations. Computer visualisation allows scientists to analyse data collected by trackers. At a time when hunting with bows and arrows are declining, the art of tracking can be revitalised and developed into a new science with many practical applications in the conservation of biodiversity.

The Art of Tracking: The Origin of Science

The art of tracking may well be the oldest science.

As far as written records are concerned, the critical or rationalist tradition of science can be traced back to the early Greek philosophic schools (Popper, 1963). A fully modern brain had evolved at a time when all humans were hunter-gatherers. Yet the same brain that has been adapted for the needs of hunter-gatherer subsistence, today deals with the subtleties of modern mathematics and physics (Washburn, 1978).

This apparent paradox may be resolved if it is assumed that at least some hunter-gatherers were capable of a scientific approach, and that the intellectual requirements of modern science were a necessity for the survival of modern hunter-gatherer societies.

The art of tracking, as practised by contemporary trackers of the Kalahari, is a science that requires fundamentally the same intellectual abilities as modern physics and mathematics (Liebenberg, 1990). It may even be argued that physicists think like trackers.

A characteristic feature of the scientific knowledge of hunter-gatherers is the anthropomorphic nature of their models of animal behaviour. This anthropomorhic element is not necessarily unscientific. On the contrary, it may well be a result of the creative scientific imagination. Anthropomorphic projection has been noted as an essential and important element in scientific work (Holton, 1973).

In nuclear physics, the experimenter's preconceived image of the process under investigation determines the outcome of the observations. This image is a symbolic, anthropomorphic representation of the basically inconceivable atomic processes (Deutsch, 1959). When a scientist has such a visual image, the nature of the seeing or sensing is almost as though he/she felt like the object being visualised (Walkup, 1967). In thinking about a phenomenon they are interested in, some physicists, even in highly abstract theoretical physics, may more or less identify themselves with, for example, a nuclear particle and may even ask: "What would I do if I were that particle?" (Monod, 1975).

The symbolic power of useful scientific concepts lies in the fact that many of these concepts have been importing anthropomorphic projections from the world of human drama (Holton, 1973).

In the art of tracking the anthropomorphic way of thinking arises from the tracker's need to identify him/herself with the animal in order to anticipate and predict its movements. The tracker must visualise what it would be like to be that animal within that particular environmental context. In the process of projecting him/herself into the position of the animal, the tracker actually *feels* like the animal. In doing this the tracker must ask: "What would I have done if I were that animal?".

To be able to do this the tracker must know the animal very well. But in the process the tracker superimposes his/her own way of thinking onto that of the animal, thereby creating a model of animal behaviour in which the animal is understood to have certain human characteristics.

Considering the role of the anthropomorphic way of thinking in science, it is by no means obvious why a physicist should think in such a way. On the contrary, it would appear to be a rather paradoxical way to understand highly abstract concepts. On the other hand, it is quite clear why a tracker should think in such a way. This may well suggest that the creative scientific imagination had its origin in the evolution of the art of tracking.

The differences between the art of tracking and modern science are mainly technological and sociological. Fundamentally they involve the same reasoning processes.

The implication of this is that there is no reason why traditional trackers cannot be employed to conduct research in a modern context.

Trackers in Scientific Research

Apart from knowledge based on direct observations of animals, trackers gain a detailed understanding of animal behaviour through the interpretation of tracks and signs. In this way much information can be obtained that would otherwise remain unknown, especially on the behaviour of rare or nocturnal animals that are not often seen.

Expert trackers can give valuable assistance to researchers studying animal behaviour. Combining traditional tracking with modern technology, such as radio tracking, may enable the researcher to accomplish much more than either method could accomplish on its own.

In the past trackers have been used in research on animal behaviour, but received little or no recognition for their contributions (see Bothma and Le Riche, 1984, 1990, Eloff, 1984). Recently some researchers have recognised the contributions of trackers by including them as co-authors of papers. (Berger *et all*, 1993, 1994, Stander *et al*, 1997, 1997).

In particular, Stander *et al* (1997) quantifies 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 document data and conduct their own research independently.

The employment of trackers in research would require the highest level of expertise in spoor interpretation. To interpret spoor the tracker must have a sophisticated understanding of animal behaviour. There is in principle no limit to the level of sophistication to which a tracker can develop his or her expertise.

However, the main obstacle is the fact that the best traditional trackers often cannot read or write. To overcome this a user interface for a pen-based hand-held computer was designed for people who cannot read or write.

User Interface Design

The field computer project started as an Honours project in the Department of Computer Science at the University of Cape Town (Edge, Foster and Steventon, 1986).

At the outset the point of departure was that 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.

In many fields computers tend to replace people. In contrast, the field computer was designed to empower people and enable them to extend their abilities. Rather than replacing human skills, it makes these skills more valuable.

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.

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 (icons) corresponds with the tracker's interpretation of natural signs (animal tracks). The tracker therefore has a natural ability to connect a sequence of artificial signs corresponding with a sequence of natural signs.

The field computer system uses the tracker's ability to interpret signs, thereby capturing a source of information about animal behaviour and ecosystems that were not previously available.

The Field Computer System

The field computer enables trackers to record all significant observations they make in the field. Computer visualisation 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 an integrated Global Positioning System (GPS) automatically records the location of observations.

The menu includes icons that enables 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.

Karoo Pilot Project

The field computer system has been tested by two of the authors, Karel Benadie and James Minye, for more than two years in the Karoo National Park.

Although they cannot read or write, they have been using the Field Computer to record their observations in the field and download the data onto the PC by themselves. They have therefore demonstrated that they can use the computer independently.

The data they collect are very detailed. For example, shifts in rhino feeding behaviour can be seen every two months, shifting from the rainy season through to the dry season.

In addition they record spoor of rare or nocturnal species that are not normally monitored. They record virtually everything that they find interesting in the field. This may make it possible to monitor long term trends that would not otherwise be noticed at all.

Initial field tests indicate that a tracker can generate more than 100 observations in one day. They highest number so far has been 266 observations in one day, and 473 observations over a three-day period.

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

Social Benefits

Perhaps the most significant benefit is the prestige that the field computer gives to trackers who previously were held in low esteem.

Co-authors Benadie and Minye found that using the field computer has given them an incentive to refine their skills and have made their work in the field more meaningful. For the first time they can get recognition for the work they have done.

Creating employment opportunities for trackers provides economic benefits to local communities. In addition, illiterate trackers who have in the past been employed as unskilled labourers can gain recognition for their specialised expertise.

The employment of trackers will also help to retain traditional skills, which may otherwise be lost in the near future. This has cultural significance in that communities will be able to make a unique contribution to conservation. This will create a sense of cultural ownership of conservation, which may well be one of the most important contributions traditional tracking can make.

Namibia Pilot Project

A pilot project has been started in Namibia in Caprivi and will soon include traditional San trackers of Nyae Nyae in the Kalahari. This project involves local communities in the monitoring of wildlife in areas where subsistence hunters and gatherers utilise natural resources.

The objective would be to determine whether utilisation of natural resources is sustainable or not.

The main obstacles that need to be overcome will include logistical and technical support in maintaining a computer system in remote wilderness areas. If successful, this project will demonstrate that it may be feasible to use computer systems in virtually anywhere. This could have far reaching implications for the conservation of biodiversity.

An exiting aspect of this project is the prospect of hunters who still hunt with the bow-and-arrow going from an oral tradition straight into the computer age.

Kruger National Park

While the Karoo and Namibia pilot projects are testing the system on a small scale, the other extreme will be tested in the Kruger National Park.

A revision of the Kruger National Park Management Plan has identified larger spheres of monitoring than in the past (van der Merwe, pers. com.). A large part of this monitoring will need to be conducted by field rangers who have previously been overlooked due to social and cultural biases in management's approach to managing the Kruger National Park.

In the past this was done by section rangers, of which there are 22 in the Kruger National Park. However, although an excellent story-line of historic interest, the traditional rangers' diary had little scientific relevance. The main problems revolve around non-standard format of information received from different rangers, the inclusion of various levels of subjectivity and the incompleteness of some of the information.

The objectives outlined in the Management Plan will involve so much paper work that field rangers will never be able to cope with data gathering. In addition, it will be impractical to gather and analyse such large quantities of data with paper forms.

The proposed project will involve the application of hand-held computers that will enable field rangers, of which there are 220 in the Kruger National Park to collect data that can be analysed in a meaningful way by scientists and managers. By using the field computer technology, methodologies will be developed that will interpret the Kruger National Park Management Plan into monitoring objectives across an unprecedented range of needs that could not be met using the antiquated section ranger's story line diary.

The field computer system will empower the semi-literate field rangers workforce to participate in a meaningful way in the scientific monitoring of biological diversity. In this way members of local communities will indirectly be involved in the scientific management of the park.

The prospect of generating more than two million observations per year covering virtually the entire ecosystem will make this one of the largest and most detailed scientific monitoring programmes.

Computer Visualisation of Data

A simple query system allows the user to display observations for any selected period on a map. 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.

Computer visualisation will make it possible to analyse vast quantities of data in a meaningful way.

Global Environmental Monitoring

Human impacts on nature are becoming increasingly severe. To deal with unpredictable global climatic change will require new and innovative ways to monitor the environment.

The field computer system integrates traditional knowledge with state-of-the-art computer science, making it possible to gather large quantities of data at a level of detail that was not possible before.

If this system can be implemented in national parks and wilderness areas throughout the world, all the information gathered may be available globally over the Internet. It is therefore possible to develop a system that can monitor the ecosystem on a global scale on a continuous basis.

Kruger National Park Management Plan

A workshop was held in 1997 to identify management criteria that should form the basis of an extended monitoring programme (Wrench, pers. com.). The monitoring programme will include:

1. Aquatic

- Floods: date and time, peak, rise, duration, fish migration, fish breeding, dislodging of trees, etc.
- Feeding behaviour of target species.
- Fish: fish kills, approximate numbers, species and size class influenced, possible cause, date, time of day, etc.
- Fish ways: mass migration, predation of fish, dysfunction of fish ways, etc.
- Seasonal rivers: onset and duration of flow, fish migrations, fish kills, etc.
- Large pans: dates containing water or dry, observed biotic activity.
- Fountains: same as large pans.

2. Animal Biology

- Feeding behaviour of target species, e.g. impact of increasing elephant density on vegetation.
- Carnivores: lion, wild dog and cheetah data, e.g. group composition, group structure, location, deaths, disease, behaviour.

- Rare or endangered species, such as black rhino (same as above).
- Amber species – a certain number of species are classified as "amber" if they are considered threatened but not endangered.
- Data deficient species – where there is no or limited data available. These may include small or nocturnal species that are difficult to monitor. Even opportunistic data collected by field rangers would be useful, including information from tracks and signs.
- Collared and/or marked animals.

3. Alien biota and disease

- Distribution and density of alien plants and animals.
- New species – location of newly identified alien species.
- Identification and location of dead or diseased animals.

4. Illegal exploitation of animals and plants (poaching)

- Date and location of incident.
- Species concerned.
- Usage, e.g. medicinal, market, own use.
- Details of people involved, arrests, etc.

5. Patch Dynamics

- Episodic events, e.g. outbreaks of mopane worms, rodents.
- Fire extent: ground truthing for validation of satellite images, extent of burns, intensity of fires (patchy or clean burns).
- Large scale vegetation patch observations, e.g. vegetation die offs.
- Elephant movements and damage, e.g. ringbarking, tusk marks in specific tree species.

Conclusion

Over more than a hundred thousand years hunter-gatherers developed a highly refined perception of nature through the interpretation of signs. Urbanisation and technology have blunted the senses of people and alienated them from nature.

At a time when hunting with the bow-and-arrow is dying out, the field computer system may help to revitalise the art of tracking and develop it into a new science with far-reaching implications for the conservation of biodiversity.

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