Making local knowledge matter

Supporting non-literate people to monitor poaching in Congo

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ABSTRACT

This paper describes a project initiated by non-literate indigenous people to equip their own "citizen scientists" with rugged smartphones running adapted software that enable them to share some of their detailed environmental knowledge in ways that improve the sustainable management of their forest. Supporting local people to share their environmental knowledge in scientifically valid and strategically targeted ways can lead to improvement in environmental governance, environmental justice and management practices. Mbendjele hunter-gatherers in the rainforests of Congo are working together with the ExCiteS Research Group at University College London to make their local knowledge about commercial hunters' activities improve the control of commercial hunters and diminish the harassment they often experience at the hands of "eco-guards" who enforce hunting regulations. Developing and deploying a system for non-literate users introduces a range of challenges that we have tried to solve. Our Anti-Poaching data collection platform, running on Android smartphones, is based on a decision tree of pictorial icons and employs various smartphone sensors to augment observations. We describe its development here.

Keywords

Citizen Science, Mobile Sensing, Development, Conservation, Natural Resource Management, Social-Environmental Justice

1. INTRODUCTION

Sustainable natural resource management is the most significant development challenge facing humanity today. The scale of the issues involved and the inadequacy of existing paradigms means that there is an urgent need for innovative solutions to enable scientifically informed sustainable resource management of key environments. The world's tropical rainforests are one such environment. One obvious area for developing new paradigms to enhance sustainable management is to support local people to share their environmental knowledge more effectively so they can manage these areas of unique biodiversity themselves and improve environmental governance, environmental justice and management practices.

This paper describes the collaboration between a group of non-literate indigenous Mbendjele hunter-gatherers (Pygmies) living in the rainforests of northern Congo-Brazzaville and the ExCiteS group [43] at University College London to develop ICT tools that will enable the former to communicate their knowledge of illegal activities in their forest areas to the appropriate authorities responsible for controlling such activities. Having participated since 2006 in mapping their key resources to protect them from destruction or damage during logging activities on their land [19, 26], some Mbendjele members approached Lewis with the request that they would like to record commercial hunters active in their forest areas in order to improve hunting and gathering and their own safety, but also to improve law-enforcement, and reduce corruption and abuses of local people by "eco-guards".

Developing and deploying a system for non-literate users in the rainforest introduces a range of social, practical, technological, and security-related challenges that we describe here. Semi-nomadic Mbendjele have no experience of western style schooling and are non-literate, they live in small camps in remote forest areas inaccessible by road and without electricity, very variable mobile network coverage, and with 90 % humidity, dense canopy cover and frequent rainstorms. The technological challenges include developing hardware and software that can be integrated to allow Mbendjele to collect information and report illegal activities with minimal delay, to charge the devices and transfer the collected data; and cope with weak GPS signal caused by the dense canopy. Finally, there is a security issue since if Mbendjele are caught recording the illegal activities they could suffer violent reprisals. Participants are fully aware of these risks and have helped us to develop strategies to address them. Here we describe what these solutions are.

Overview.

We start by sketching the wider context of this work in section 2. Next, section 3 introduces the specific case of the Mbendjele and the challenges of building a platform that will enable them to collect information about illegal poaching. In section 4 we discuss a number of existing platforms for mobile data collection. We describe the current prototype of our Anti-Poaching platform in section 5. In section 6 we discuss an initial evaluation of the platform. We conclude this paper and reflect on future work in section 7.

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2. CONTEXT

Addressing the needs of some of the poorest people living in Central Africa is challenging on many levels: Technical and practical infrastructure is weak or non-existent, especially in rural areas; Governance is weak[1] and undermined by resource fuelled conflict and war (Congo-Brazzaville 1997-2000, Democratic Republic of Congo 1996-on going); National economies are dominated by multinational companies extracting raw materials (oil, minerals, timber) and increasingly promoting large scale land use change by establishing palm oil plantations. In conjunction with the political instability, predatory market forces and rapidly expanding industrial activities, now climate change is adding a new, unpredictable dimension to the rapid environmental changes experienced by the Mbendjele and other forest-dependent people. These are among the poorest citizens of these countries and the groups most dependent on natural resources for their livelihoods, yet they are rarely consulted in decisions over the attribution, or involved in the management of the areas they depend upon for their livelihoods. The overwhelming tendency for natural resource management in Central Africa since the 1990s has been to establish protected areas that exclude local people in conjunction with the aggressive promotion of industrial resource extraction in adjoining areas [5, 24, 46]. This may be appropriate in certain cases, but ignores the current need to support indigenous and local forest people to maintain or re-establish sustainable use of the resources they depend upon. Mbendjele are proud of their semi-nomadic hunter-gatherer lifestyle and wish to be able to maintain it, but without access to good forest, this becomes difficult. As logging roads open up increasingly remote areas to commercial activities, more and more of the forest's resources are drawn out onto national and international trade networks and forest people watch their resource base diminishing. Having worked in the region with the Mbendjele since 1994, Lewis has witnessed many of these changes and has been discussing them with his Mbendjele friends and colleagues.

In 2005 the local logging company, *Congolaise Industrielle des Bois* (CIB), decided to become Forest Stewardship Council [13] certified as environmentally and socially sustainable in their forestry operations. Part of this required them to respect the rights and resources of indigenous and local forest people. A solution was developed by a consortium [19, 26] that introduced Mbendjele to the use of rugged Personal Digital Assistance (PDA) devices, portable GPS receivers and bespoke software that allowed non-literate users to record observations using a pictorial decision tree [25, 27]. The resources they documented as valuable to them were then verified and removed from the cutting schedule of the timber company. The data was presented as a map that some of those involved in the data collection began to learn to read. The Mbendjele most closely involved were impressed when they witnessed the seriousness with which the timber company treated these maps and their effectiveness in communicating vitally important information about their key resources across a cultural boundary[2], which had seemed insurmountable to them just a year or so earlier.

Inspired by this positive experience, in May 2010 the president and the secretary of the Mbendjele association requested Lewis to develop a similar tool to deal with another pressing issue for them: the activities of commercial poachers. As we discuss in detail in section 3, commercial poaching is a growing problem, not only due to over-hunting, but also due to reprisals made against Mbendjele and other local people by government-run "eco-guards" supposedly responsible for controlling commercial hunters. Because the devices used in the previous logging-related project are bulky and expensive and the software proprietary, Lewis & Haklay decided it would be better to create a new, generic and adaptable platform that enables people with no or limited literacy – both in the strict and the broader technological sense – to engage in mobile data collection, visualisation and analysis using off-the-shelf smartphones and tablets running open source software.

The proposed development of this generic platform and its application in the case of the Mbendjele fight against poaching became part of a series of funding applications that eventually enabled us to form a multi-disciplinary research group at University College London. The Extreme Citizen Science (ExCiteS) group [43] was founded in late 2011 and was officially launched in February 2012. Our mission is to build (ICT) solutions in collaboration with participating communities to promote their control of their land and resources – by allowing citizens to capture their extensive local (environmental) knowledge, report in-situ observations, visualise and transmit accumulated data, and share it with selected outsiders. The goal is to go beyond "traditional" citizen or community science projects [9, 14, 16], which typically target educated people in affluent areas of the world, by developing methodologies, tools and platforms to support any community regardless of educational background or literacy to participate in scientifically valid data collection and analysis, and be effectively (re)integrated into the management of areas and resources they depend on [15, 33]. We believe this *extreme citizen science* approach can have transformative potential to deal with major sustainability challenges by making scientifically valid datasets available to a wide range of users in formats that are accessible to all of them – even if they are not literate. While our first project is focused on the situation of the Mbendjele, we plan to develop reusable and flexible solutions that contribute to making ICT more accessible for communities around the world, as well as more adapted to their development needs. This is motivated by the observation that many communities living in the remaining areas of great biodiversity have rarely been exposed to modern education or technology, yet they have detailed and sophisticated knowledge about these important environments. The tendency to impose draconian floral and faunal management laws and practices designed by technocrats and politicians from outside the affected areas has disenfranchised such people from any say or involvement in the management of the areas their livelihoods depend upon. One way to tackle this problem is to directly involve them in environmental monitoring so they can participate in further debate from an informed perspective. This requires tools that allow the collection and visualisation of spatial data by non-literate users in ways that facilitate analytic reflection. Ultimately this would enable communities to build so-called *community memories*: evolving, shared representations of the state of their environment, their relationship with it, and any threats it faces [37, 38]. By providing local communities with the means to monitor and analyse environmental trends we seek to support their reintegration into key decision-making processes and create durable solutions for

[1]Transparency International's latest Corruption Perceptions Index places Cameroon at 134, Congo-Brazzaville at 154, and the Democratic Republic of Congo at 168 out of 182 [41].

[2]From non-iterate hunter-gatherers to university-educated expatriate company managers.

cost-effective, large-scale environmental management through providing all stakeholders with good quality information in readily comprehensible ways.

In this paper we discuss the developments and learning so far as we seek to support the Mbendjele to regain some control over their environment. Although the project is on-going, we take this opportunity to present our current prototype of a novel data collection platform using mobile phones, as well as a preliminary evaluation of this tool. In the future we will extend this platform with visualisation and analysis tools for non-literate users, as well as generalise the platform for other use cases, in order to realise the ExCiteS vision.

3. CASE: HELPING THE MBENDJELE TO FIGHT POACHING

The Mbendjele are the indigenous people of northern Congo-Brazzaville. As expert hunters and gatherers of wild produce they move through huge areas of forest over the course of the year visiting different resource centres and following social opportunities as they arise. They are very concerned about over-hunting by commercial poachers in their traditional hunting grounds. The hundreds of vicious wire snare traps the poachers leave concentrated in small areas ravage animals indiscriminately and pose a danger to hunter-gatherers and their children as they move in the forest. The poachers operate from small camps dispersed in the forest and are typically armed with shotguns, Kalashnikovs and rifles – posing a threat to locals, especially those who try to meddle in their activities. They enjoy relative impunity because they bribe eco-guards or other law enforcers and are often part of larger networks supported by local elites keen on profiting from this highly lucrative business. Eco-guards looking for easier targets often visit Mbendjele and other local communities where they too often resort to violence and abuse. The Mbendjele experience this as unacceptable persecution for something that they see as their birth right – to live by hunting and gathering wild foods from the forest as their ancestors have since time immemorial. It is also a major concern and preoccupation of civil society, local conservationists from Wildlife Conservation Society (WCS) and the logging company CIB. Until now, they have not found an effective way to capitalize on the Mbendjele's extensive knowledge of poachers' whereabouts and habits to control them more effectively.

In May 2010 two prominent Mbendjele asked Lewis to design a new tool that would allow them to record this knowledge – similar to the earlier tool used to map their resources to protect them from damage from logging activities [25, 27]. Together they visited the offices of the WCS manager, who helps to organise the eco-guard patrols, to propose the idea and to discuss which issues they would like to monitor and, from the eco-guards point of view, which observations (e.g. sightings of poacher's camps, traps, dead animals, etc.) would need to be recorded to effectively arrest the poachers. Icons representing different issues and observations were sketched out by Lewis until participants felt satisfied that all aspects were covered. The resulting decision tree design was applied in the Anti-Poaching application we discuss in section 5.

Challenges.

Deploying ICT systems it the rainforest and putting devices designed for educated, literate people in the hands of non-literate forest people presents numerous foreseeable and unforeseeable difficulties. We tried to pre-empt the most obvious of these as we developed a suitable solution.

The low or lacking literacy of the users of the system was the most obvious of these. This covers literacy in the original sense (i.e. knowing how to read and write) as well as numeracy and so-called "technological literacy" (i.e. the ability to use and understand ICT tools). Most Mbendjele have difficulty reading the numbers on banknotes, and almost none can write their own name. They have never had any formal education, nor used computers or mobile phones. Non-literacy is a huge obstacle to using such devices because virtually any standard user interface (UI) contains textual and numerical elements. A related challenge is language: only a handful of Mbendjele speak any international languages and their own language is spoken by few outsiders. *Lingala*, the local lingua franca, is spoken by many Mbendjele as well as the eco-guard managers.

The overall technical challenge is to provide the Mbendjele with a platform that allows them to report poaching-related activities in the forest and feed this information into a central database in time for appropriate control activities to be organised successfully. This necessitates a mobile device that can withstand the adverse conditions of the African rainforest: dust, mud, high humidity levels and frequent rain. Moreover the device needs to be robust such that it does not break when roughly handled for extended periods of time by people who have no experience in dealing with delicate electronic equipment. Furthermore, it should be equipped with a GPS receiver that is sensitive enough to get location fixes under dense forest canopy within a reasonable amount of time (e.g. max 5 minutes). Finally it should be relatively cheap – so as to be affordable the non-governmental organisations and potentially indigenous communities themselves. In terms of software, we found that although there are many existing frameworks and applications for mobile data collection (see section 4), the nature and requirements of this project made off-the-shelf solutions impractical.

There are also numerous practical challenges that we have to tackle. In the developing world the power grid is often unreliable with plenty of spikes and outages, causing problems like fried laptop batteries and hard disks [29]. In the rainforest however there are usually no power facilities at all – nor does the traditional lifestyle of communities like the Mbendjele require it. This, combined with the high power demands of smartphones, poses a major challenge. Furthermore, although it is fast expanding, cellular network penetration and coverage remains limited in developing countries, especially in vast, sparsely inhabited areas [29]. However, since the early 2000s and the realisation of the value of the local African market for network operators, masts are being erected even in small towns in remote, forested areas, specifically targeting workers receiving regular wages in resource extraction industries such as logging, plantations and mining. Deeper into the forest there is typically no network coverage, let alone Internet connectivity, which is problematic because we need data to be uploaded to and synchronised with a central database.

Finally, perhaps the most challenging problem is that of security and more specifically personal safety. Given the nature of the data collection activity, the consequences of an Mbendjele member being caught in the act by poachers could be dramatic, possibly even fatal. Therefore the equipment should be discreet, easy to carry around and if necessary to hide or discard. Moreover the true purpose should be deniable – in part by restricting access to the data collection software.

4. RELATED WORK

To this day, paper-based survey forms remain widely used for information collection in the field across many scientific disciplines. However, this approach is time-consuming, costly and error prone [23]. Advances in ICT have enabled collecting data via online forms and mobile devices. By allowing data to be fed directly into an electronic database, digital forms can make data collection more efficient, cheaper and less error-prone compared to the traditional paper forms [23, 31, 36, 40]. Moreover, digital data collection makes it easier to standardise procedures and replicate projects [4]. Furthermore, electronically stored information is easier to transmit, share and analyse [4, 31]. In the context of humanitarian aid, development or conservation projects in the developing world, there is a particular interest for mobile data collection platforms running on PDAs or mobile phones, which do not require a fixed networking and power infrastructure and are relatively cheap compared to laptops or desktop computers [6, 18, 45]. For our anti-poaching project we have evaluated various mobile data collection platforms and applications, before deciding to develop our own platform – albeit based on an existing one. Below we briefly present the most important examples along with their limitations and restrictions.

CyberTracker & EpiHandy.

The first mobile data collection platforms targeted handheld computers or PDAs [22]. CyberTracker [8] and EpiHandy [12] are examples of such early, PDA-based platforms. CyberTracker was developed in the 1997 to be used by non-literate animal trackers to record observations [17, 35] but evolved into a general purpose data collection tool that has found many applications relating to conservation and indigenous people [3, 10, 11, 30]. EpiHandy was a similar platform. Nowadays both are outdated, primarily because they rely on expensive and equally outdated PDA devices that lack the processing power and built-in sensors of today's smartphones. Currently there is an effort underway to port CyberTracker to Android [8]. In 2008 EpiHandy was ported to run on mobile phones, albeit on the now already outdated Java ME CLDC platform [42], but the project has been discontinued since.

EpiCollect.

The next generation of mobile data collection platforms target mobile phones and smartphones. EpiCollect, an initiative of Imperial College London, is a successful example of such a modern platform. It is developed under an open source license and is primarily geared towards epidemiological and ecological studies [1, 20, 28]. It facilitates form-based data collection in the field using smartphones – supporting both Android and iOS[3] devices – from where results can be uploaded to a central database. Forms are described in a simple XML-based mark-up language. EpiCollect also offers online tools to design forms (without having to write XML), data visualisation (using Google Maps) and basic analysis. However, because it is designed for literate scientists it is heavily dependent on textual interaction and does not support the use of pictorial icons and decision trees.

Open Data Kit.

Another modern mobile data collection platform is Open Data Kit (ODK), which is developed as part of an open source project led by the University of Washington [2, 17, 32, 44]. The ODK platform is designed to be modular and consists of tools such as ODK Build, Collect, Aggregate, Manage, etc., which cover various aspects of the process. For instance, ODK Build allows users to design form-based surveys, which are described in an format based on the XForms standard [47]. These surveys can then be deployed to Android devices running the ODK Collect application, which facilitates the actual data collection and the uploading of results to a central database. At this central point ODK Aggregate and ODK Manage may be used to visualise, analyse and manage incoming data. ODK supports surveys that include text input, multiple choices, check boxes, audio recordings, photos or videos, GPS location and barcodes.

Although it requires verbose and complex XForms structures[4], it is possible to implement a decision tree consisting of pictorial icons. But due to extensive use of textual information in the UI, the standard ODK Collect application would be too confusing for non-literate users. However, because it is open source, we decided to use ODK Collect as the basis for our prototype platform and modify it to suit our needs.

5. PLATFORM PROTOTYPE

Over the course of February and March 2012 we put together a prototype of our Anti-Poaching data collection platform. Below we discuss the different hard- and software components and touch upon some important design choices.

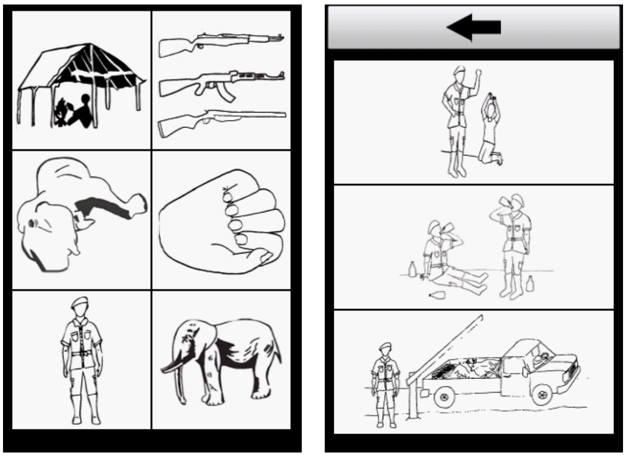
5.1 Hardware

In order to withstand the harsh rainforest conditions and not-so-gentle treatment by the Pygmies we have looked for a rugged, water-resistant smartphone. There are an increasing number of such devices on the market. However, most are targeted at military or industrial clientele and have correspondingly high price tags. Fortunately recently some mainstream smartphone vendors have introduced much cheaper rugged devices aimed at the general public. The device we ended up choosing is the Samsung Galaxy Xcover [34], an Android-based smartphone that has a durable body, a scratch-resistant Gorilla Glass [7] screen, and is IP67-certificatied [21], which means it is dust tight and waterproof up to 1 m. The choice for an Android-based device was a deliberate one. In comparison with rival platforms, most notably Apple's iPhone, Android devices come in a much wider variety and price range (some costing less than US$ 100). Targeting a platform that is used by many different vendors should also allow us to avoid vendor lock-in and dependency on a handful of brand-specific, aging models, which is what happened to early PDA-based platforms like CyberTracker.

To charge the devices in the forest we tried 2 solutions. The first is a combination of a rollable solar panel and an external auxiliary battery that stores energy for later use. This allows electricity to be generated during the day and used to charge devices at night (as the people doing observations will likely be on the move during the day). However due to the dense forest canopy there is little direct sunlight that reaches the ground level, which makes it hard to use solar power to its full potential. Thus, we looked for another method of producing electricity. The best alternative we found was the *Hatsuden Nabe*, a Japanese-produced customised cooking pan that converts thermal energy from a fire into electricity that

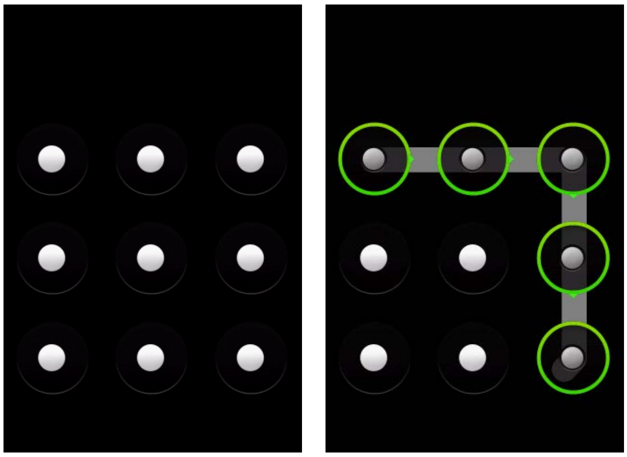
[3]The operating system of Apple's iPhone, iPad & iPod Touch.

[4]By using input constraints.



(a) Main menu (b) Eco-guard behaviour

Figure 1: Parts of the decision tree interface



(a) Lock screen (b) Drawing unlock pattern

Figure 2: Access control by means of unlock pattern

can be used to charge electronic devices while cooking food or boiling water [39]. This solution is ideal for the lifestyle of the Pygmies who have easy supplies of firewood and always keep a fire going to cook food and to keep animals at bay.

5.2 Software

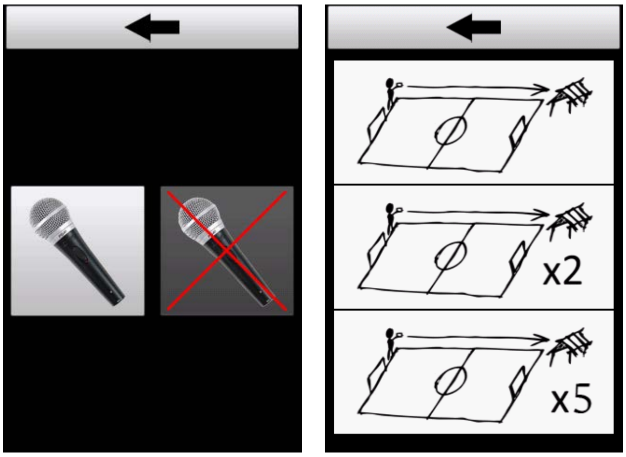
As noted above our Anti-Poaching application is built on top of a modified version of the ODK Collect application for Android[5]. To overcome the literacy barrier we used a pictorial decision tree as in Lewis' earlier project [25, 27]. One modification we made to ODK Collect was to let the application run in full screen. Hence the Android status bar – normally shown at the top of the screen, showing the time, battery level, signal strength, etc. – and the title bar of the application itself are hidden to avoid confusing or distracting our users. We also made several other modifications to ODK Collect in order to remove any textual information. What is left is a minimalistic, entirely graphical interface in which icons are arranged in a grid, as shown in figure 1.

For the choice of icons and their arrangement in the tree we stayed true to the design agreed upon in May 2010. The icons represent various signs of poaching activity (e.g. camps, footsteps, hidden weaponry, traps, rotting or abandoned game, smuggling of bush meat or trophies), cases of abusive or corrupt behaviour by eco-guards (e.g. harassment of locals, drinking on the job, taking bribes), and sightings of live animals or other natural resources that indicate good forest health. For optimal readability the icons were drawn in a clear, naturalistic style in black and white. Because the decision tree had been discussed beforehand we were reasonably confident that it would be comprehensible and relevant to the users. In the spirit of user-centred design, we presented the Mbendjele with our prototype in April 2012 to get feedback for further improvements. This initial evaluation is discussed in section 6.

In the current version the decision tree consists of 59 distinct icons spread across 4 levels. Every observation starts with the main menu shown in figure 1(a), corresponding to the top level of the tree. The user can navigate to a lower level by touching on one of the icons on the touchscreen, and is then presented with a new, more specific set of choices. At every level except the top one a back button allows users to go back one level in case they made a mistake, as shown in figure 1(b). When the user has reached the bottom level of the tree this means a complete, specific observation (e.g. a recently abandoned poachers camp) was described, at that point the observation can be complemented with an audio recording, a photo or a video, as a means of providing additional information and evidence. After that the device will try to obtain geographical coordinates from the built-in GPS receiver in order to geo-tag the observation. While waiting for the coordinates the user is presented with a waiting screen. When the coordinates are obtained (or a time-out has passed) the observation, along with multimedia attachments and coordinates is automatically saved to the memory card of the device, without any further user interaction. To indicate that the data was successfully stored a beep sound is played. The application is operating in continuous loop, meaning that at the end of each complete observation it goes back to the main menu, ready for the user to make a new observation.

As noted in section 3, it is important to restrict access to the Anti-Poaching application such that the true purpose of the device can be hidden or denied. Because the users are non-literate, conventional authentication mechanisms such as passwords and PIN codes are not suitable. Instead, we use a pattern unlocking mechanism. When the application is opened the user is first presented with a screen consisting of 9 dots, as shown in figure 2(a). To get past this screen the user must draw a previously agreed on pattern – only known to approved participants – by sliding a finger over the dots on the touchscreen, as shown in figure 2(b). If the pattern is recognised the user will be presented with the main menu shown in figure 1(a). Even for literate users this mechanism typically works faster than typing a password or PIN and the patterns should be easy to remember for non-literate people too. This type of access control is well known to Android users, as it is one of the ways the operating system allows users to unlock their device. However, here we use it to restrict access to an application, rather than to the device itself, meaning that all other, "innocent" functionalities remain unobstructed.

[5]Our version is based on v1.2 RC1 of ODK Collect. The original codebase covers roughly 24,000 lines of Java and XML code of which we modified about 17 %.



(a) Audio recording (b) Distance estimation

Figure 3: Features that employ smartphone sensors

By default ODK Collect relies on the standard Android applications for audio recording and the photo/video camera. However these interfaces contain textual elements and a plethora of features and settings, all of which are confusing and distracting for our non-literate users. To tackle this issue we have extended ODK Collect with our own minimalistic audio recording interface, shown in figure 3(a). In this interface, there are only three buttons: the back button (consistent with the decision tree interface); the record button which is represented by a microphone, a familiar concept to some members of the tribe; and finally the stop button. We have not yet created a replacement for the standard photo/video camera application but plan to do so in the near future – such that all aspects of the data collection process become equally effortless and comprehensible.

Making observations of (possibly) active poachers' camps represents an obvious risk of being spotted or caught. Hence the Mbendjele prefer to stay at a safe distance. In order to still record the position of the camp (or another hard to approach place) we have implemented an innovative feature that allows users to point the device in the direction of the camp and provide an estimate of the distance that separates them from it. The combination of the user's own position (obtained through GPS), the bearing (registered using the built-in compass), and the estimated distance allows us to compute the approximate position of the camp. The question then is how we can ask these users, who are unfamiliar with standardised distance units and have no or limited numeracy skills, to express distance. The solution we have invented is to let them express distance as a number of football pitches, a concept they are familiar with from seeing them in logging towns. As illustrated in figure 3(b), the UI allows users to select a distance of 1, 2 or 5 football pitches. Few Mbendjele can read numbers, however, due to the sensitivity of the project only key participants and co-developers will get to use the application and we can expect those individuals to at least recognise the numbers 2 and 5 from handling 2000 and 500 CFA banknotes – something not all their peers have had the opportunity of doing very often. While this method of determining positions is not very accurate in terms of distance, it is in terms of direction. This is the key information that the eco-guards need to find a camp. As always the accuracy of the user's own position depends on GPS signal reception conditions. Nevertheless this feature at least allows to record a reasonable indication of the position of potentially dangerous places.

6. INITIAL EVALUATION

Over the course of April 2012 our prototype platform has been tested by the Mbendjele. Testing was coordinated by Lewis, who also coached the involved tribe members.

6.1 Hardware

We provided the Mbendjele with a set of 4 Samsung Galaxy Xcover phones. To increase battery life we tweaked settings and removed or disabled any unnecessary applications and background services. We also supplied a Hatsuden Nabe unit, a rollable solar panel and an auxiliary battery.

Mobile devices.

As far as the smartphones is concerned, the results were promising. The devices proved to be robust, they withstood the dust and humidity of the forest, as well as the treatment by our users, which involved usage as part of night rituals.

On 3 out of 4 devices we had applied a protective screen cover to avoid scratching. However, it turned out the protective cover itself was easily scratched and reduced screen readability and responsiveness to touch. However, the unprotected phone was left without even the faintest scratch. This proves that Gorilla Glass is as tough as promised and that there is no need for additional protective covers. Furthermore, the screen brightness was adequate and the users quickly learned how to operate it by touching.

The built-in GPS receiver also proved to be adequate. In clear areas it took up to 2 minutes to obtain a first fix, and up to 5 under forest cover. Obtaining subsequent fixes only took 10 to 25 seconds in most cases. However one of the phones performed slightly worse than the other 3, because it would sometimes take significantly longer to get a fix.

We were impressed by the battery life of the phones. With ordinary use it could last for several days and with limited use for a week. However, in some rituals it seems that the users tended to use the phones screen as a torch – at one point a large spirit was doing a swirling and twirling dance while being illuminated by two of the phones! The people also discovered they could use the phones to record their music. Obviously such activities cause the battery to drain dramatically quicker. This could be a concern and in the future it may be necessary to somehow limit such unintended usage. However, it is also possible that if the devices serve additional purposes the users would be more likely to treat them with care and remember to recharge them in time. Hence, it will require further observation and research to determine if, when, how, and to what extent unintended usage should be curbed.

Charging the devices.

The Hatsuden Nabe proved to be the most appropriate power source for the situation, although it takes more time to recharge a phone than by using the solar panel. It takes approximately 3-4 hours to fully recharge a phone, during which the water in the pan needs to be replaced up to 6 times. However it provides a 60 % charge in about 1.5 hours with only 2 water changes. Figure 4 shows the pan in use. The tests were conducted with the Hatsuden Nabe HC-5, which has a diame-

Figure 4: Charging a phone with the Hatsuden Nabe

Figure 5: An Mbendjele records an observation

ter of 14 cm. In the future we may switch to the larger WHC8 (22 cm) or WHC12 (30 cm) model, which should enable faster recharging [39]. Because there is an abundant supply of firewood in the rainforest the need to collect some more of it was not felt as a burden. The main weakness of this solution is that it requires a watchful eye to ensure that the cables do not get burned, that the water is regularly replenished, or that the pot does not topple as wood logs burn down.

With the solar panel in direct sunlight it took about 2 hours to recharge 2 phones at once. It took about 4-5 hours to charge the auxiliary battery, which could then be used to recharge multiple devices. As expected the solar panel turned out to be an excellent solution when sedentary in an open space, but is not practical while on the move or when under dense canopy.

Some Mbendjele seemed to have no difficulty to understand and execute tasks such as connecting the phones for charging or understanding when a phone is powered off due to a flat battery. Others seemed to have trouble and required more coaching and repetition to familiarise with these tasks.

6.2 Software

Due to the secrecy of the project it was not possible to train as many users as we would have liked for testing the software. However, those who did get the training quickly grasped the concept of the decision tree and of pictorial icons representing observations. Although users suggested a number of improvements to the graphics to be clearer and more easily recognisable, overall they could quickly work out what each icon represented. While black and white is generally fine, as it enhances readability, there were some icons for which the Mbendjele asked to have colour added – mostly red. In general, the users were satisfied and comfortable the grid arrangement of the icons. They were not confused by the fact that some screens showed 6 square icons, such as in figure 1(a), whereas others showed just 3 rectangular icons[6], as in figures 1(b) and 3(b). They seemed to like the beep sound that signal successful completing of an observation. However the electronic sound is very distinctive in the forest and could lead to the user being noticed by poachers, therefore the users would prefer a sound like a bird call or something natural, which would be less startling. Another possibility we are considering is to replace the sound with a vibration.

[6]This is due to the need to include more detailed drawings, which work better if displayed across the full screen width.

The users had no difficulty in learning to unlock the devices using the pattern unlocking mechanism; though it was confusing and difficult for some at first with some guidance and repetition they quickly learned to master this task.

The audio recording part of the application was very popular among the users and they got the hang of it much easier than the camera. Audio recording was extensively used while the users took the phones on an unsupervised 24 hour walkabout. On the other hand, the photo application was difficult for people that were not used to two-dimensional representations, but when likened to using a gun – "aim, hold firm, and fire", people started to get the hang of using it. Some common issues were the need to avoid putting their fingers in front of the lens, to hold the device still and coping with the slight delay between the pressing of the shutter button and the actual picture being taken. The save button was the most difficult aspect of this, and pretty much impossible for most. This confirms the need to replace the standard camera interface with a simpler, text-free one. The quality of the camera itself is adequate: the pictures look clear and vibrant and are reasonably sharp, except when taken in low light conditions. The users expressed the desire to be able to take multiple photos, videos or audio recordings per observation, which is not possible in the application as tested.

Finally, the users seemed to have no difficulty understanding the concept of pointing the phone in the direction of a dangerous place in order to record the position from a distance. However, they requested for some changes in the football pitch icons to be clearer. Furthermore, the individual tribe members that will conduct most of the data collection were indeed able to understand the concept of 1, 2 and 5 football pitches. However, it is difficult to know what will happen when non-literate people are using the handhelds unsupervised.

6.3 Data Collection

As part of the training they received and subsequent testing members of the Mbendjele collected a total of 427 observations, 151 photos and 40 audio recordings. Figure 5 shows

Figure 6: Visualisation of observations

one of them recording an observation. Because this was a first evaluation of the platform no risks were taken and hence the data does not yet reflect actual poaching activity. After the devices had been returned to London we extracted the data and made an initial visualisation using Google Earth. In figure 6 a subset of the observations is shown.

7. CONCLUSIONS & FUTURE WORK

Our Anti-Poaching data collection platform takes proven concepts [25, 27] but adds innovative features based on the affordances of today's smartphones and does away with the restrictions of outdated, vendor-specific devices and proprietary software. Moreover, the use of alternative power sources vastly increases the flexibility of the platform. The initial evaluation demonstrates that the prototype works as expected but it also resulted in helpful suggestions for further improvements which we will implement.

To make the data collection platform effective it needs to be complemented by a flexible means to transmit data to a central server. We are currently working on such a system by having background service running on the phones which regularly checks for network coverage. The participating Mbendjele regularly visit – or get sufficiently near to – small towns with coverage and the software must use such opportunities to transmit accumulated data. Transmission should happen automatically via SMS, Wi-Fi or GPRS/3G, depending on availability, without any user interaction. Transmitted data must be compressed and encrypted to minimise transfer times and offer security.

The next big step in our collaboration with the Mbendjele will take place during the Spring of 2013, when we plan to deploy and improved version of the data collection tool as well as the data transmission infrastructure. This will also be the first opportunity for the ExCiteS technical team to meet the end-users of the system, experience the rainforest conditions first-hand and consider how collaborative design can be implemented under these circumstances.

Due to the need for secrecy this particular project will likely remain fairly limited in terms of the number of participants. However to ensure the relevance of our system beyond this use case, we are already preparing for other, larger-scale projects in other contexts and countries. To support these we are currently working to make the platform more flexible. One notable hurdle is the verbosity and complexity of the decision tree description in XForms. This problem will have to be dealt with – possibly even by moving away from ODK Collect – because it stands in the way of the generalisation of the ExCiteS platform: ideally people with only limited computing skills should be able to design and deploy their own decision trees, suited for specific projects beyond our own. Enabling such flexible reuse will be one of the main challenges in the near future. Part of the solution will be to create a Web-based tool for designing decision trees.

To conclude we should stress that the ExCiteS vision is still taking shape and that many questions remain. One avenue for future research concerns the visualisation and analysis of collected data. Under the moniker of *Intelligent Maps* we plan to design a novel, dynamic approach to presenting spatial data and emerging trends, in ways comprehensible to non-literate people. Other open questions relate to determining the optimal logistic, social and financial conditions that would enable extreme citizen science projects to scale up and be sustainable over long periods of time. We expect that applying our solutions in a variety of contexts will create opportunities to try out new concepts and answer open questions.

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