The Batphone

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Bat populations provide a good indication of the health of ecosystems. The Indicator Bats Programme has developed a citizen scientist approach employing bats as a probe for its global biodiversity-monitoring system. In this note, we introduce the development of a smart phone application for Android and iOS that considerably reduces the technological barriers to participation in this data collection exercise.

I. Background

For over a century, volunteer enthusiasts have contributed their time and effort to help catalogue a wide variety of flora and fauna across the world [5]. During the past decade the wider availability of online collaboration tools, crowd sourcing and social networks, enabled citizen science to attract a wider audience and appeal. One of the projects pioneering this approach is the Indicator Bats Programme [4] established by the Institute of Zoology and the Bat Conservation Society in the UK. iBats has enabled a network of hundreds of citizen scientists across the globe to collect geolocated ultrasound samples and related environmental information thus supporting extensive measurement of bat populations.

iBats has been developed in response to the declaration of the Convention on Biological Diversity of the United Nations Environmental Programme, which called for the implementation of biodiversity monitoring programmes across the world. Bats are of particular relevance because they are a biodiversity indicator species, in the sense that presence and size of their population within a particular habitat provides a good overall indication of the health of the related ecosystem [3]. This is because they have specific ecological requirements and are particularly sensitive to environmental change. In particular, bats are sensitive to climate change due to their dependence on nocturnal flying insects (also sensitive to changes in temperature) and to pollution through poisoning of their prey base.

iBats works in cooperation with national bat preservation initiatives to build a database of ultrasound recordings carried out over particular transects. Volunteers follow the same transect multiple times every year during the July-August bat season to create a historical record that identifies the evolution of such populations over time. These records are stored within a web-based system, requiring individuals to register and manually upload their recordings. The survey itself is carried out while driving at low speed (to avoid Doppler effect interferences). Until recently, the protocol specifying the recording process had been developed around the use of several pieces of bulky equipment: an ultra-sound detector, a GPS unit, a HP Jornada PDA and a mini-disk recorder. The volunteers used a (paper) notebook to record relevant environmental conditions, for example the presence of even light rain would affect species detection algorithms.

II. The app

The bulky and rather out of date equipment was recognised as a barrier for participation for many volunteers. The total cost of the kit is around 1,600 USD, which is prohibitive especially for volunteers in low-income countries. Due to the track record of our group in this area [1, 2] in early 2009 iBats requested the development of an app that would allow them to replace all devices with a smart phone. In addition to replicating existing functionality the phone would also be used to make notes and to automatically upload data to the iBats server, replacing the cumbersome manual process.

We quickly identified the main challenge to be whether it would be possible to replace the bat detector by using the phone hardware to capture and digitize echolocation signals. Such signals typically range between 1 and 160kHz (although some studies place the upper limit higher at 200kHz) and are well outside the range of human hearing, which for adults

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is in the range of 20Hz and 16kHz. It should probably come as no surprise that phones are not well equipped to cope with these frequencies.

Bat detectors come in different types and typically provide some feature to convert the high frequencies to audible sound. For example, the high-quality so-called time expansion detectors, work by sampling a brief section of the bat ultrasound and converting into digital, which is then replayed at a slower rate, typically 10 times slower. Consequently, a sample captured at 100kHz is lowered to 10kHz and thus within the human audible range. In this case, the iBats protocol requires the time-expanded sample of the first 320ms of every second to be recorded in full CD quality. An additional consideration was that microphones built into phones are specifically designed to respond well to the range of frequencies of the human voice. In particular, at ultrasound frequencies wind and other weather conditions interact with the immediate environment to produce high pitch sounds that significantly affect the quality of the captured signal and indeed the majority of bat detectors have developed special provisions to minimize these effects.

It soon became evident that we could decrease the number of required devices to two, and thus considerably reduce the complexity of the user experience, but that it is not possible to completely replace the bat detector. At a cost of 300-400 USD, high quality detectors require high frequency ADC and DAC, which in several of the devices we examined were implemented using FPGAs. Fortunately, very recently a number of stand-alone ultrasound microphones have come to the market incorporating both quality microphones and ADC components that provide appropriate signal quality.

III. Outcomes and Public Response

The iBats app for Android and iOS released in 2011 provides the exact same high quality of information as the legacy protocol and thus maintains consistency with the historical record already captured in iBats. The two applications provide identical functionality and have been implemented natively on each platform. On the first day of their release, we recorded more than 3,000 downloads to a large extent due to the extensive coverage of the event by the press including articles by the BBC, Scientific American, several UK dailies, and other news agencies across the world. Perhaps unsurprisingly the greatest attraction of these articles was the opportunity to make reference to the Caped Avenger as several of the tiles reveal.

Fig 1. Jon Russ of the Bat Conservation Society using the iphone app with a Tranquility bat detector.

Today, there are over 6,000 active installations across both platforms though the actual contributors to the iBats effort are less than half this number. Our understanding is that this is primarily due to the restrictions placed by the requirement for an ultrasound microphone (at current cost of approximately 170-200 USD) or for a dedicated time-expansion bat detector.

Nevertheless, the iBats app has been and continues to be a considerable success. It has significantly extended the reach of the programme and allowed more volunteers than ever before to be involved and contribute data. With the rapid reduction in the price of ultrasound microphones currently underway, we anticipate that in the medium term the overhead of participation for aspiring citizen scientists will be reduced to the simpler requirement of phone ownership.

References

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