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Whale Trails – a smart phone application for whale tracking

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Abstract: Whale watching is undertaken by millions of tourists every year around the world and forms an important industry for a number of countries. Recent changes in migration patterns of whales in particular Humpback whales maybe attributed to climate change. Identifying movement and resting spots of whales can provide opportunities for adaptation of the whale watch industry in times of uncertainty. Such tracking of movements and activities of whales can be collected using smart phones. Smart phones are a readily available technology and capable of complex computations. They have abilities required for tracking including GPS location, maps and a compass function. Here an application that incorporates the complexities of ocean surveying with a simplistic interface so that a wide range of users can apply the program was developed. This was accomplished by use of a simple interface, which incorporated the acquisition of a user's latitudinal and longitudinal coordinates, calculating the bearing of a whale to a user, and sending the data to an online spreadsheet from which a Geographic Information System (GIS) routine can calculates tracks. The generated data allows for the estimation of changes in the distribution and movement of whales to improve whale-watching experiences and adapt to future changes.

Keywords: smart phone application; citizen science; whale watching; community-based participatory research, climate adaptation

1. BACKGROUND

Whale watching is a multi-billion dollar industry and was estimated at 2.1 billion USD in 2008 (O'Connor et al., 2009) with more than 13 million whale watchers per annum. One of the main target species for whale watching is the Humpback whale (*Megaptera novaeangliae*). It is widely distributed throughout the world's oceans, an acrobatic species and most populations are recovering from decades of whaling. A new challenge for the migratory Humpback whale is a climate change induced shift of currents, salinity and plankton (Durack et al., 2012; Hays et al., 2005). These changes could lead to animals leaving previously used areas and move to other more suitable areas. This is a risk for the growing whale watching industry, which relies on the same resting and breeding grounds being visited by whales annually. Little is known about fine scale movement patterns of humpback whales, albeit being an important "natural resource" (Meynecke et al., 2013).

Collecting information on whale movement is essential to understanding migratory patterns and detecting temporal and spatial shifts of whale presence. Identifying the movement and behaviors of whales can provide opportunities for adaption of the whale watching industry. Long-term scientific behaviour studies of marine mammals are costly and have small chances of funding. It is therefore necessary to apply citizen science and use crowd sourcing. Information of movements and activities of whales can be collected using smart phones. Smart phones are capable of taking complex geometrical readings, different types of computations and are a readily available technology (Dufau et al., 2011). They have multiple types of sensors and capabilities required for tracking including GPS location, maps and a compass. The most popular smart phones in the market are currently Android and Apple based products (Griffith, 2012) making them a preferred platform for collecting data through the wider public.This is an opportunity for the public to assist and contribute to research on whales.

Previously smart phone applications (apps) have been used successfully in research and conservation (Worthington et al., 2012). Bateman et al. (2013) developed an app for capture-mark-release biological studies on iOS and Android operating systems. This app is using pre-programmed fields, checkboxes, drop-down menus, and keypad entry. Popular conservation smart phone apps include the mapping of invasive species (Brigham et al., 2009) such as the ‘Smarter Ambrosia Reporter’. A recent specialised development is ‘Whale Alert’ for near real-time warnings of the presence of North Atlantic right whales (*Eubalaena glacialis*) based on acoustic buoys in shipping lanes in and around a marine sanctuary developed by Conserve IO. ‘Spotter Pro’ is another app on iOS that facilitates capturing data on field sightings of marine mammals and uploading them to a common database. Citizen science and crowdsourcing have been reviewed in more detail elsewhere (e.g. Conrad and Hilchey, 2011; Gura, 2013).

The aim of this project was to develop an app to track and monitor Humpback whales (Whale Trails©). This app needs to gather data about whales and their behaviour patterns through an integrated GPS system. Users of the ‘Whale Trails’ application should be able to capture locations of spotted Humpback whales simply by pointing their device, using the app, directly towards a whale; its bearing is then captured and the data gets sent to an online database for further use by researchers. The target group is whale watchers in the northern and southern hemisphere low-latitudes where Humpback whales are common and have their breeding grounds.

2. DESIGN AND IMPLEMENTATION

2.1 Developing components and process

Firstly a mind-map of the apps components was developed (Figure 1). Following a linear approach the app was to consist of a start tracking, view map, info and exit page. The concept is similar to ‘Epicollect’ (Aanensen et al., 2009) or ‘iNaturalist’ as ‘Whale Trails’ is designed to collecting data including georeferenced information and photographs.

To establish a track of a whale, the bearings and location of the mobile device user have to be stored and displayed in the device and from there the data will traverse to an open server and later used in a Geographic Information System (GIS) software such as ‘ArcGIS’ or ‘Quantum GIS’ for processing. Measuring the intercept of the bearings can produce a track based on multiple points from different users. A track consisting of multiple sighting points is still produced by one user based on the selected distance between user and whale and user location. However, a more accurate track can be calculated with two or more simultaneous user by taking the bearing and GPS location from each user to calculate intersection points. Based on analytical geometry the intersection point (u) of two lines based on two user locations (z, w) with bearings (east of north in degrees) *theta* and *phi*, respectively can be calculated using the distance (t) with the following equations:

$$(x,y) = z - w$$

$$t = (y \sin(\mathit{phi}) - x \cos(\mathit{phi})) / \sin(\mathit{theta}-\mathit{phi})$$

$$u = z + t(\sin(\mathit{theta}), \cos(\mathit{theta}))$$

A Javascript for manual external processing is available but integration into a GIS platform is desired.

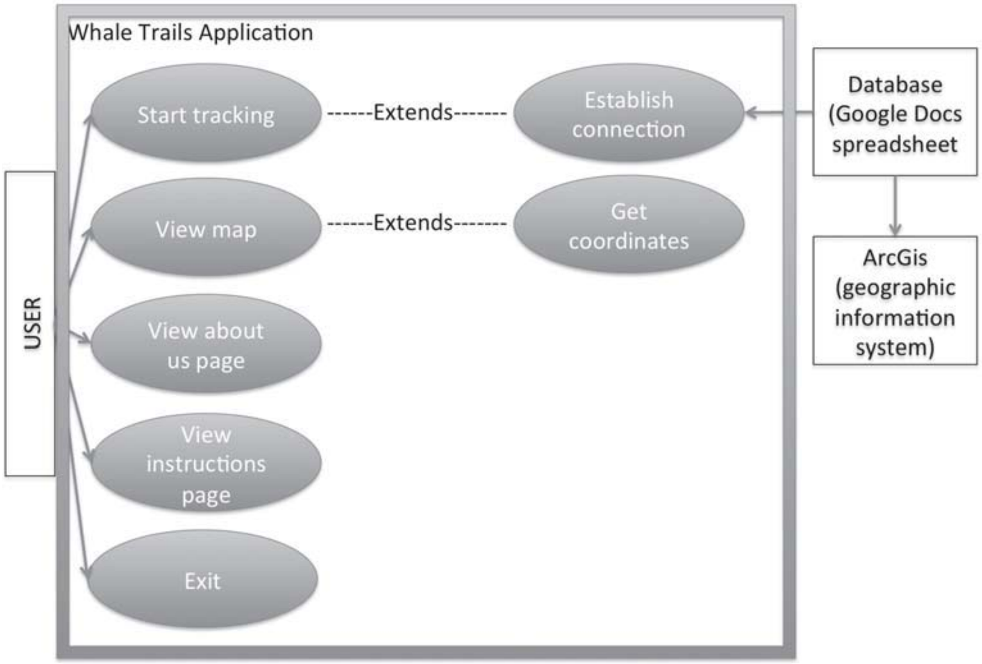

Figure 1. Mind map for 'Whale Trails'.

2.2 Coding

For coding and testing Apple based smart phones Xcode (for Objective C) was used. Xcode is an integrated development environment (IDE) containing a suite of software development tools provided by Apple for developing software for OS X and iOS. The Android based app was developed in Java programming language using the Android software development kit (SDK). The SDK includes a comprehensive set of development tools. To study the source code the officially supported IDE Eclipse android SDK was used with the Android Development Tools (ADT) plugin.

2.3 Testing

Testing the functionality and adjusting the app was a major component of the app creation. The focus was in particular on simplicity and user-friendly structure and appearance. Unit testing and integrate testing were performed every time a new component was completed. It ensured components of the application worked as expected and minor bugs were directly addressed. System testing occurred when the application was close to be finalised. Test cases were run to optimise the usability. The server side and associates were also tested. The iPhone app version was tested on iOS 4 and higher, on iPad and iPhones 4s. For the Android based app version it was necessary to run it on a number of smartphones with different specifications, ensuring that the app runs smoothly on most phones. The Android framework includes an array of tools for testing Android applications. The JUnit framework is an extension of those tools allowing the application to be tested with a virtual device. 'Whale Trails' was tested on platform 1.5 (Cupcake) to 4.0.4 (Ice Cream Sandwich) covering most devices at the time (Android Developers, 2013). User acceptance testing was conducted after all other tests. The goal was to see whether end users can easily accept the app and to what extend the users feel that the app is useful. Navigational errors and user behavior were recorded.

3. RESULTS

3.1 System architecture and application layout

The application was structured to maintain a user flow from one page to another with one user input per page. The application always starts with a menu page that is the root or parent page to other pages. From the menu page a user can navigate to five other pages. The first is the 'start tracking' page which leads onto four other pages associated with the whale tracking page function, when a whale has been "tracked" and the appropriate data has been successfully sent to the database the user can then view a summary and be guided back to the menu screen where recent whale tracking data on a world map can be viewed, read the about us page, read the instruction page, track another whale or exit the application (Figure 2).

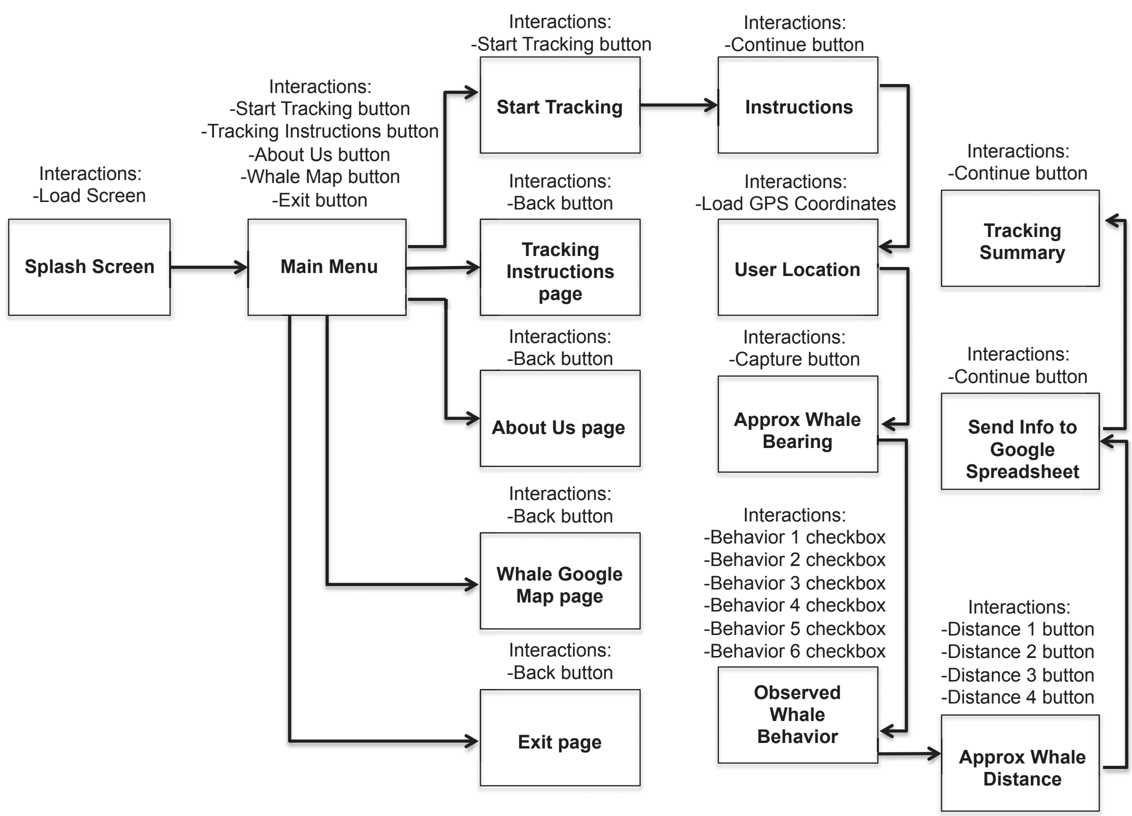

Figure 2. System architecture of the application.

The layout of each page in the application was designed for functionality, aesthetic appearance and accessibility. Each layout has a page heading, so the user knows where they are in the app. The elements on the page have been designed so that the page content will wrap around according to the screen dimensions of a mobile phone. Larger images have also been used so that image quality is retained across multiple devices. Each page in the application is a linear off-shoot of the main page; except for the whale tracking function pages. The layout for the tracking function is a linear stream, allowing for the user to only go forward through each of the steps (Figure 3). Back tracking steps at different intervals were not desired as the chance of supplying inaccurate data increases. Data collection can not be done without mobile reception (location required). Before the data is sent, the user has the chance of correcting the whale's activities only, as the rest of the calculated data is dependent on the mobile phone's hardware.

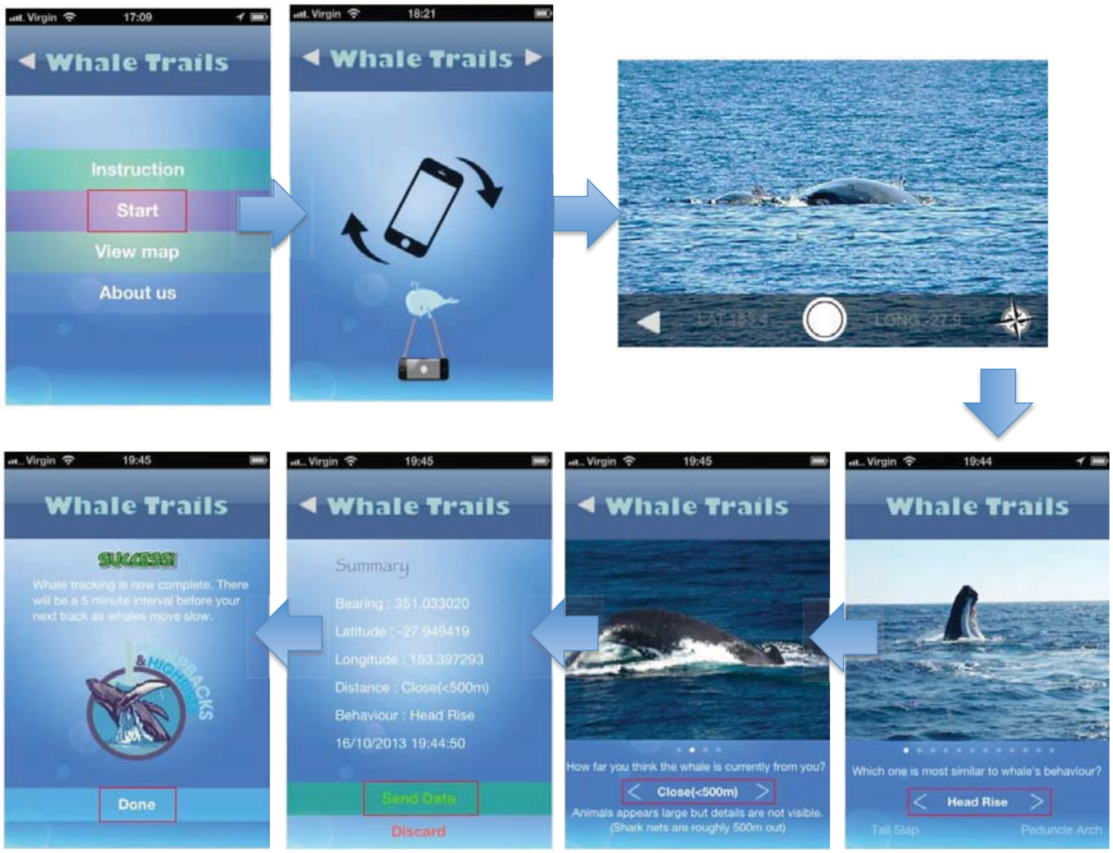

Figure 3. Screenshot samples of the GUI layout 'Whale Trails' from an iPhone 4s.

3.2 Core functions

A number of features were added to the app that enables successful data capture. Data are gathered by the user location using geolocation API (Ahas et al., 2007), user bearing through the phones compass (only possible if phone is rotated at least once) and user ID. Individual users are assigned a unique identifier so that data integrity can be retained. This can verify whether the collection of data a user provides is relevant and allows for filter routines in the data base. Unique identifiers can also be used to group users tracking particular whales. The estimated track of a whale depends on the triangulation of multiple users through a manual process on an external GIS platform but a less accurate track can also be created by a single user (Figure 4). To provide estimation of a whale's location from a single user the apparent distance of the whale to the user can be used. Four images are providing different estimated distances and the user chooses one of the four images which best represents the whale's distance in respect to themselves.

Google Docs provides a free of charge accessible server for data storage and also allows for data to be stored in a simple spreadsheet format. It is also possible to create a form, where data input takes place into predefined positions on the spreadsheet. The smart phone has access to the server and after it is utilised by the user, the details are removed from the phone. The only access to the spreadsheet is by login and password, protecting the data from unauthorised access and rewrite. For convenience, the spreadsheet can also be exported in a variety of file formats making it accessible for GIS.

Figure 4. Sample whale track as shown on Google map with single user location marked as a blue dot.

4. SUMMARY AND DISCUSSION

'Whale Trails' is an app using smart phones to capture data on Humpback whale behavior and location. It is designed as a 'whale watching' application targeted to whale enthusiasts and tourists on whale watch vessels and allowing researchers to further process collected data. The focus during app development was on functionality, usability and efficiency; keeping the information and user actions to a minimum. This resulted in processing times of 5 to 35 seconds for locating and describing one whale sighting. The user interface design requires the user to press predefined options as buttons or as check boxes. There is no need for the user to be able to input a custom field like a text box, limiting the amount of inaccurate and increasing the processing time. The user can see the result of the captured data on a view map function.

When developing apps for citizen science and crowdsourcing it is most important to create logical and intuitive steps. However, there are still errors possible where user input is required to take a compass bearing to the sighted whale, misinterpretation of behavior and the wrong species being targeted. Some of these errors were identified and minimised through user acceptance testing. This included buttons, locating the user, bearing calculation, website loading, tick boxes and text boxes. First field tests using a preliminary implementation of the 'Whale Trails' app proved its concept. Testers were able to capture observations after a short introduction. Improvements proposed include further testing of the application on more users and mobile devices. Future uses for this application could involve the adoption of methods used in other, similar applications. It is desirable to include the process of calculating tracks into the application and linking individual users to allow seeing other users tracking the same whale. The identification of individual whales using quality fluke and dorsal images would be possible with further development.

With graphics and camera technology in smartphones further developing and gradually improving, there is potential in the biological sciences to identify particular species, individuals or behaviours even from further away or use image recognition for further processing field data. Apps such as 'Whale Trails' are making science more accessible for the community and are the beginning of a new era in citizen science. They allow research campaigns that also have an important educational role and therefore should further be fostered by the science community.

5. ACKNOWLEDGMENTS

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