Recording Vocal Interactivity among Turtles using AUVs

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Abstract

This paper is the reflection of a brainstorming session at the Dagstuhl Seminar 16442 VIHAR in which potential costs and practical building constraints were made secondary to consideration of emerging technologies that might combine robotics and animal research. We have identified a practical use-case for an emerging technology and propose modifications to the devices that would enable their use in our case. The paper describes how turtles may be tracked by autonomous devices that (a) provide a corpus of their behaviour, and (b) eventually help to protect young turtles by identifying key habitats used by hatchlings.

Index Terms: Autonomous Underwater Vehicles, Turtle behaviour, Vocalisations, Image processing, RCNN, Submersible devices, Tracking-robots, Conservation

1. Introduction

Vocal interactivity is assumed to take place between turtles and may provide a source of information regarding food locations, environmental activity regarding predators moving in the area, location of refuges that the turtles may be using, or changes in water current, among other possibilities. To date there has been little research into turtle vocal interaction because of scarcity of data and difficulties of recording vocal behaviour in situ.

In this paper we propose a method whereby such information may be gathered for analysis of the relation between vocal interaction and animal behaviour. In particular we propose techniques for tracking and recording hatchlings and young turtles after they have been tagged by a human and when they start to travel further afield, beyond the range of human observers. Particularly interesting is the depth information associated with their dispersal localities since this information cannot be obtained using drone technology.

Previous work has reported success in using Autonomous Underwater Vehicles (AUVs) for tracking acoustically tagged fish near Juneau, Alaska [1] . The use of AUVs and a low energy sensor for tracking jellyfish has also been proposed [2], suggesting there may be a broader range of applications for further developing this technology for use in wildlife research. We propose a similar device suitable for tracking young turtles after hatching by following them amongst the dense vegetation which forms their habitat.

If the turtles were confined to a two-dimensional surface then the tracking problem could be easily solved by the use of drone technology, but because the turtles move in a three-dimensional space, a submersible device is required. As mentioned earlier, depth information cannot be obtained using drones, but it is important information to obtain for learning about hatchling turtle movement.

Currently many scientists and practitioners in the field (wildlife biologists and volunteers, citizen scientists etc) are devoting much of their time to protecting nesting beaches and the adult females during egg laying, or rearing hatchlings in head-starting facilities [3]. These are costly, labor-intensive efforts and involve much waiting around for eggs to hatch. In spite of these efforts, populations of most species are continuing to decline and are at risk of extinction. Table 1 (from [4]) shows that more than a third of species are endangered, and one of the major issues yet to be addressed is protecting the hatchling turtles in their first years of life in a natural environment. This has been a problem due to our inability to track the location of the hatchlings after they leave their nests. Key questions regarding hatchling dispersal are a) how far they travel from their nest and b) at what depths. Additionally, budgetary and time constraints are restricting our ability to provide further protection to the turtles, but AUVs could aid our conservation efforts by directing us to the optimal habitats used by dispersing hatchlings.

Table 1: *Worldwide IUCN chelonian population assessment*

Category	Species Count	Percentage
Extinct	7	3.1%
Critically Endangered	32	14.0%
Endangered	44	19.3%
Vulnerable	58	25.4%
Near Threatened	10	4.4%
Lower Risk	66	29.0%
Data Deficient	11	4.8%

2. Capturing Turtle Talk

It is known that turtles use vocalisations to communicate [5,6]. High quality ultrasound hydraphones are currently available for recording these calls and regularly used in cetacean research. Identifying the turtle vocalisations from among the various noises found in their environment may be problematic; however this is a problem that has already been addressed by previous research with *Chelodina oblonga* turtles [5]. Individuals can be recorded in the laboratory under a training phase to determine the vocal repertoire and known vocalisations can be compared to samples acquired from the natural environment. These techniques can be used for studying any species of turtle.

There may be little need to identify which individuals are making the particular sounds in order to associate the sounds with their subsequent behaviour, since the group may respond to any call from any individual in a consistent way. Our research therefore principally concerns identifying the sounds that trigger the movements. The body of the work involves collecting representative data in the wild, recording both acoustic events and associated movements, and then training statistical classifiers to map between features of the recordings and particular behavioural patterns.

3. Incorporating a Mother-Node

To track hatchlings in the first month of their life, small submersible devices (that we refer to as turtle-tracking robots) can be adapted for remote use, recording data continuously. Information storage on the tracking robot is not a problem but there is a foreseeable difficulty regarding battery life in extended deployment. A solution can be found by using a mother-node as a local charging station as well as for data aggregation. Once a tracking robot can sense that its turtle is inactive, it can 'ping' its GPS location, store its depth, and briefly visit the mother-node for battery replacement, data/information delivery, and debris removal before returning to the pinged location, with some compensation for potential drift. In this way, a long-term record of locations and navigation behaviour can be learnt in addition to the vocal behaviour characteristics.

At hatching, each turtle in the nest is tagged with an RFID chip using standard procedures [7]. Each turtle-tracking robot will only 'follow' one specific individual from each clutch of eggs marked but because all will have been RFID tagged, it will have the ability to record the location of any nearby siblings at the same time. Multiple devices will be needed for tracking individuals in the group. In addition to the hydraphone, the tracking robot will be fitted with 360-degree image capture. By knowing the location of its target, the device will use a form of image processing to maintain minimum distance from its source, based on perspective. The captured images can later be used in the laboratory to determine the identification of other species in the hatchlings' environment.

In addition to long battery life, an optimal device would require: navigation ability, image processing facility, GPS and depth location, etc., in order to associate vocal and bodily activity with coordinates in three-dimensional space. By including the 'mother-node' in the swarm, and assuming that the pack doesn't disperse completely but stays in a relatively closely delimited area, the task of sending data back to the researcher can be performed by the larger coordinating device.

4. A Pied-Piper Robot for Turtle Protection

There are pros and cons to utilising AUVs in wildlife research. In this section we highlight what we believe are the main concerns and the main benefits that will arise from integrating fields of robotics and fields of ethology.

There may be concerns regarding invasion of privacy in this work as there has been debate about the interaction of robotic devices with species in the wild [8]. For this reason, the proposed AUV would need to maintain a minimum distance from its target specimen. There is little justifiable concern about planting the RFID chip in the hatchling as it is already established practice [7]. There is a potential for misuse of the technology for capturing young turtles for the illegal pet trade, but collecting the eggs would be easier. There may also be a potential danger to other wildlife, for example diving birds which come into contact with the submerged devices, but the chance of this actually happening is minimal.

The technology may be put to good use at a later stage of the research when it can be used as an underwater 'sheepdog' to guide hatchlings to a protected zone or safer location provided by concerned researchers in the field. In addition to tracking native species, another application of the turtle-tracking robot is to identify the locations of invasive turtle species. The technology may enable the removal of invasive species thereby protecting the natural habitats for local species.

5. Discussion and Conclusion

In this paper we proposed a system for studying turtle behaviour underwater. The system is composed of one or more small submersible devices equipped with sensors for detecting acoustic events over a range of frequencies, and 360-degree image processing around each device. Manually swappable mother-nodes provide in-situ supplies and collect local data. We detailed the scope and limitations regarding the movement of the tracker robots and their 'relationship' with their turtle subjects, and we described how the small AUVs will be able to follow the young hatchlings and serve a practical use in providing additional information about the turtle locomotion and location of refuges.

The purpose of the research is to better understand how turtle vocalisations relate to group behaviour and movement within the environment. The method involves recording a large corpus of hatchling vocalisations along with data related to their position in the environment and in the group. The collected data will form part of a larger study employing statistical procedures (deep nets, recursive convolutional neural networks etc.,) to find mappings between the observations. There has been relatively little understanding of hatchling behaviour because of the remoteness of the location in which it typically occurs, but when this corpus becomes available ethologists will be able to observe finer details of the behaviour. This is an important tool for the future of conservation.

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