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24/7 Automatic Detection of Whales Near Seismic Vessels Using Thermography

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SUMMARY

Detecting whales at sea by visual observation for mitigation purposes is inherently difficult and personal intensive while restricted to daylight hours. These caveats are overcome by the system described herein, which employs a state-of-the-art thermographic infrared scanner in conjunction with a learning computer algorithm to automatically and reliably detect whale blows. The stand-alone system provides detection, verification and documentation of each ship-whale encounter, allowing a retrospective review of every mitigation decision taken aboard. The system has been developed over the course of 5 years and was thoroughly tested in polar waters during 7 expeditions to the Arctic and Antarctic, accumulating 5871 hours of operation. Of these, 3472 hours, were analyzed with various learning automatic detection algorithms, which discovered about 4500 whale blows in this data. Direct comparisons of auto-detections with concurrent whale sightings by visual observers (double blind setup) confirm a very high degree of detection reliability within 2-3 nautical miles from the ship in subpolar and polar environments. The system, when used as a an "assistant", allows a single marine mammal observer to efficiently monitor the ships entire surroundings and to take instantly and retrospectively verifiable decisions regarding the use of airguns, as all relevant data is automatically stored.

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Introduction

Visual sightings currently form the basis of most mitigation efforts during marine geophysical prospection. Whale sightings mostly rely on the spotting of a whale's blow, which rises to several meters height and remains visible for a few seconds. To conduct such observations for multi-week periods on a 24/7 basis, large teams of observers are necessary to compensate for observer fatigue and the limited human field of view. Moreover, visual observations are restricted to daylight hours.

The alternative use of thermal imaging techniques for mitigation in the context of offshore oil exploration was discussed as early as 1987 by Greene & Chase [1987], who considered the approach promising, yet the technology of the time not ready to allow long distance, full perimeter, 24/7 monitoring. Perryman et al. [1999] were the first successfully employed an IR system to study the grey whales at relevant ranges (several kilometres) off central California. They report that grey whales blows were clearly visible in both their day and night recordings, and that they detected whales at distances in excess of 4 km from the survey site each year. However, their system only provided a narrow fixed field of view of 3.4° x 6.8° and required manual picking of events (i.e. blows).

Material and Methods

These constraints have been overcome in this study by using a state-of-the-art, actively stabilized rotating thermographic scanner in conjunction with a learning automatic detection algorithm. The scanner provides five 360°-images per second, each of 7200x576 pixels and with a temperature resolution of 0.004K. The resulting video data is processed by a customized software package, Tashtego (Figure 1). It allows data acquisition, life video display, event tagging (automatically or manually) and saving of relevant data. Events may be detected in real time by an automatic pattern recognition algorithm or manually picked by an observer, resulting in saving the relevant video sequences permanently. Events are displayed in "zoom" windows in an endless loop to allow instant verification. To aid mitigation decisions, the real time display (Figure 1, upper half) of the thermal image is augmented by lines indicating user-selectable radii around the airguns (e.g. 500m, 1000m, …) and a corridor of selected width, indicating an "exclusion strip" along the ship's projected path. Additional GUI (graphical user interface) features allow tracking points of interest, retrospective viewing of events and automatic preparation of documentation.

Figure 1 *Screen shot of graphical user interface (using 3 wide-aspect displays). Top: 360° real time view of the ship's surroundings. Middle left: 10 verification windows showing 10s-loops of latest events. Middle right: 10s loop and tracking view of latest event location. Bottom left: Control panels.*

Examples

We evaluated our ship based system on 7 expeditions into polar oceans and operated it for a total of over 245 days at sea. It is independent of daylight and exhibits rather constant detection probabilities within 5 km. Examples of auto-detections are given in Figure 2. It outperforms an alerted observer in terms of number of detections due to its unlimited field of view and parallel processing capability.

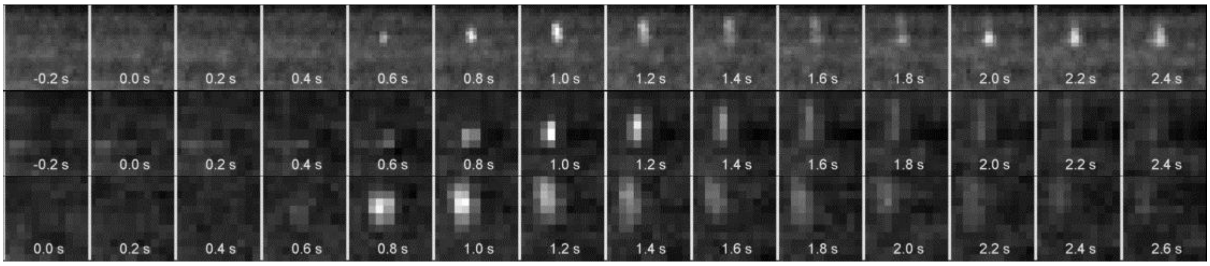

Figure 2 *Top: Whale blow at 1200 m distance during daytime. Middle: Whale blow at 2300 m distance during daytime. Bottom: Whale blow at 1300 m distance during night-time.*

Conclusions

This system allows both real-time auto-detection and verification of events along with their systematic documentation and offers the additional benefit of night-time vision. Our results demonstrate that, at least in (sub-)polar waters, thermal imaging allows reliable, continuous marine mammal mitigation on a 24/7 basis, the common operational mode for most hydroacoustic activities at sea.

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