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Building a Sensor System for a Large Scale Arctic Observatory

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Abstract. The Climate-ecological Observatory for Arctic Tundra (COAT) is a long-term research initiative for real time detection, documentation and understanding of climate impacts on terrestrial arctic ecosystems. COAT is a collaboration of several Norwegian research institutions under the umbrella of FRAM - High North Centre for Climate and Environment. The study areas include the bioclimatic extremes of the terrestrial Arctic, low arctic coast of Norway and high arctic Svalbard.

An important part of the observatory is sensors placed in the environment to observe wildlife and plants. Current sensor packages are fairly robust and work well for small to medium scale deployment. For larger scales, however, there is a clear demand for better management and control.

This paper summarises some current experiences with deploying cameras and some of the challenges that we intend to address in an up-coming project where we aim to increase the capability of scientists to handle a larger number and diversity of sensor types and variation in deployment while minimising human traffic and impact in the monitored environments.

To build this type of observatory at increasing scales, we expect to use robust programming architectures, open modular sensor packages, on-line processing, monitoring and configuration management and a range of communication technologies to cope with variations in connectivity.

Keywords. arctic, observatory, ecosystem, camera-trap, tundra, distributed, large scale, remote, monitoring

Introduction

The COAT project [1,2] uses several types of sensors and observation such as earth observations by satellites, snow observations, meteorological observations, camera traps, microphones and manual observations of wildlife and plants. This paper focuses on camera traps, but the discussion is also relevant for some of the other sensors used, or intended to be used, in the project (such as microphones).

Currently, COAT has about 275 cameras traps[2] deployed, and will increase this to about 450 in the near future. The camera traps are mainly placed in remote locations where there is little to no infrastructure available in the form of roads, electricity, or wireless connectivity.

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[2]The project currently uses Scoutguard and Reconyx cameras.

Frequent inspections should be avoided as it is both costly to send people out to the remote tundra areas, and extra human traffic may disturb the environment, reducing the quality of the observations.

1. Environmental Challenges

Figure 1. Image from one of the COAT camera traps under the snow.

One of the novel camera traps used in the COAT project is a tunnel (see Figure 1) designed to capture images of small mammals[3]. The traps are placed in an area before the first snowfall and retrieved in the spring. Inspection is thus not possible during the entire arctic winter as the cameras are covered by snow. Environmental challenges include snow entering the tunnels, or the trap being flooded, drowning the camera.

Figure 2. Image from one of the COAT camera traps with bait and eagle in view.

Some of the traps use bait to lure wildlife in front of the camera [4,5]. Figure 2 shows an example image from one of the camera traps. Challenges include timing the replacement of bait, as animals dragging the bait out of view, or variations in feeding, may result in periods with fewer animals in view. Regular visits are required to resupply bait, but this may disturb the area before new bait is required.

Typically, tundra vegetation is sparse and shallow. The camera installations will thus stand out and be tempting targets for curious animals, or, for example, reindeer with itching antlers. Even cameras mounted in trees may be knocked out of position, or knocked down from the trees. Such incidents will not be noticed until the next inspection round, which can mean that weeks or months of observations are lost while the camera dutifully inspects snow or bark.

All of this suggests that being able to monitor the status of sensor packages remotely would increase the quality of the observations. Periodic sample images may also indicate whether something has happened to the traps that requires intervention. Remote monitoring has also been suggested in [6], which provides a survey of issues with available cameras used in camera traps.

2. Management Challenges

Reconyx is among the leading producers of wildlife cameras, providing robust cameras that work well under harsh conditions [7,8]. Visual inspection of the cameras reveals that they are designed to survive rough weather and that they are intended to be set up and serviced without carrying a computer to the location they are deployed.

This design, however, introduces a potential for configuration errors that add up when we scale up the number of cameras. COAT researchers have experienced that field personnel have set up cameras and forgotten to start them before leaving the location. Verifying a configuration setting requires that one manually goes through the configuration options using the buttons inside the camera box (see Figure 3). It is easy to misconfigure or forget to verify a setting, which has resulted in cameras using the wrong configuration for an entire season, or at least until the next time somebody services the camera.

The camera can read configuration files stored on the memory card when it boots, but the configuration files will be deleted immediately after being read. We expect that the reason is that the configuration files can include settings such as date and time that should not be reset every time the camera boots. It does, however, mean that cameras have reverted to default configuration (for unknown reasons that may include temporary power loss) instead of being able to read the configuration from the memory card. Another problem with this property is that it is not possible to verify what configuration the camera did read, or whether anybody modified the configuration before the recording was started. Similar issues have been reported in [9] for other camera manufacturers.

Figure 3. Opening a Reconyx camera to verify the configuration.

Some configuration information can be found in the Exif data in the images, but the complete configuration that was actually used is not easily available. This also means that configuration errors may not be found until after retrieving and inspecting the images, which may happen after a second round of incorrectly configured observations have been started.

Reconyx provides a 3G module for their cameras that lets the cameras send periodic images and status information. The module, however, severely impacts battery use[3] and COAT deploys cameras in locations where 3G networks are not available. The communication also appears to be one way only, ruling out configuration downloads.

3. Post-Processing Challenges

A significant issue when scaling up the number of cameras is post-processing. Images have to be gathered from several remote locations and shipped before they are stored in a research database along with meta data describing the captured images. Any issues with gathering the data in the field (such as date and time issues, missing configuration information and image numbering) add to the complexity of analysing the data afterwards [9].

Another issue is that COAT will soon generate millions of time lapse images every year. Processing such numbers of images manually is infeasible, so we are currently investigating how the process can be automated using image processing techniques [10,11].

4. Concluding Remarks

To manage an increasing number of cameras monitoring arctic ecosystems, we are currently examining how to build a large scale distributed sensor system that will allow us to monitor a wide range of sensor packages (including camera traps), update configurations remotely and collect and process sensor data. There is a trade-off between local processing in the sensor packages and communication that may be exploited to conserve power and reduce human traffic in the area. We will also investigate whether local processing in the sensor packages can be used to provide digests, summaries, or lower resolution images that can be used for on-the fly species recognition without transferring full resolution images back to the COAT centre.

Internet of Things (IoT) technologies have been suggested for wildlife monitoring [12], and some technologies, such as low-power long-range radio communication, can be useful for managing several camera traps in a region.

Open solutions, as suggested in [9], may be essential and allow us to tailor modular sensor packages to observation needs and available communication infrastructure at specific locations. To achieve an arctic observatory that can be increased at least an order of magnitude in size, we expect that we need modular and robust software systems and open interfaces on sensors that are used in the field.

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