

## MAS 06 Imagers as Biological Sensors

### MAS 06.1 People

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### MAS 06.2 Overview

There exist many biological sensing applications where direct measurement is either impossible, extremely invasive, or extremely time consuming. For example, measuring the presence/absence of birds at a feeder station currently requires a human to watch a camera pointed at the feeder, identifying when birds arrive and leave. Similarly, measuring CO<sub>2</sub> flux from a plant requires placing the plant inside a growth chamber, destructively modifying the environment.

We propose using imagers as biological sensors by constructing a procedure that uses images to obtain approximate measurements of these phenomena. This procedure, composed of state-of-the-art computer vision, image processing, and statistical learning algorithms, will be evaluated in the context of a specific application and shown to be general through multiple instantiations. Through application, it has been found that many of these algorithms make unacceptable assumptions about their input. Providing accurate data to biologists and ecologists, though the appropriate modification of these algorithms, is the ultimate goal of this work.

### MAS 06.3 Approach

**MossCam:** When direct measurement is difficult, imagers are the missing input required to accurately model natural phenomena. Images are typically avoided in traditional sensing applications because they produce large quantities of uncalibrated data. The form of calibration required for an imager-based ecological sensor is dissimilar to that of typical sensors; there is no conveniently accessible reference that can be used to calibrate an imager used as a CO<sub>2</sub> sensor, for example. We aim to use state-of-the-art computer vision, image processing, and statistical learning algorithms to build a two step imager calibration process that can be evaluated in the context of a specific application. First, image features must be extracted that are both domain relevant and immune to changing field conditions. Second, these features are used to model the signal of interest as measured in a controlled laboratory environment.

**Animal Monitoring:** Manually monitoring the environment for the presence of animals is limited by the amount of human time that can be devoted to it. Automatically detecting and segmenting out animals from a natural scene would ease the burden of the biologist and allow observations to scale beyond what a biologist has time to view. Unfortunately, environmental monitoring applications present a challenge to current background subtraction algorithms that analyze the temporal variability of pixel intensities, because of the complex texture and motion of the scene. They also present a challenge to segmentation algorithms that compare intensity or color distributions between the foreground and the background in each image independently, because objects of interest such as animals have adapted to blend in.

### MAS 06.4 System(s) Description and/or Experiments

**MossCam:** To calibrate our imaging sensor, we must perform several laboratory experiments. The first experiment collects the target signal as measure under controlled laboratory conditions. The second experiment collects data about the camera and spectral properties of the subject, allowing us to accurately estimate the relative spectral reflectance of a fixed subject under realistic (and changing) natural illumination. The final experiment attempts to link the first two by measuring a sequences of subject, producing a repeatable trajectory of

spectra changes over time, and related those changes to the signal of interest. We separate the experimentation in this way because, in general, it is not possible to measure all the needed quantities (target signal, subject spectra, etc.) in one experiment while properly controlling the environment.

**Animal Monitoring:** Often the standard tasks of detection and tracking are intermediate steps towards a larger goal. In this work, we look at the goal of cataloging new objects from an image sequence through detection and tracking. A particular challenge of focusing on new objects is that there can be no prior knowledge of what objects will be in the image sequence. Moreover, we cannot know when the new objects appear in the sequence or the number of objects in any particular frame in the sequence. We show that by integrating background subtraction for localization and tracking for object recognition, we are able to connect detections across frames. We use localization in two ways. First, localization allows us to do away with the similar appearance constraint when objects have not moved significantly from frame to frame. Second, we can propose to the mean shift tracker new locations that are not necessarily in close proximity to the previous location. We can do this without prior assumptions on the objects cataloged, even when objects move suddenly or have very different appearances from frame to frame. We compare our approach against standard mean shift tracking and find that our approach is better able to handle sudden movements and appearance changes.



Our approach is able to recognize that detections across with little overlap are the same bird, due to their similar appearance.



Sudden appearance changes that would cause tracking algorithms to fail can be recovered through background detections.

### MAS 06.5 Accomplishments

- MossCam: we can accurately predict reflectance in changing lighting conditions we have nearly completed a model of spectra trajectory over time paper and talk at Imagesense 2008

- Animal Monitoring: We have improved our animal monitoring system by adding matching across multiple frames through our tracking and detection methods described above.

#### **MAS 06.6 Future Directions**

Animal Monitoring: We will be improving the detection and cataloging of birds through real-time appearance modeling.