Public Abstract

First Name:Xiwen

Middle Name:

Last Name:Zhao

Adviser's First Name:Zhihai

Adviser's Last Name:He

Co-Adviser's First Name:

Co-Adviser's Last Name:

Graduation Term:FS 2011

Department:Electrical Engineering

Degree:PhD

Title:RESOURCE-EFFICIENT PORTABLE VIDEO COMMUNICATION SYSTEM DESIGN FOR WILDLIFE MONITORING AND INTERACTION TRACKING

In this research, we focus on algorithm development and system design for resource-efficient portable video communication system design and their application in wildlife monitoring and interaction tracking. The capability of seeing what an animal sees in the field is very important for wildlife activity monitoring and research. We design an integrated video and sensor system, called DeerCam and mount it on free-ranging animals so as to collect important video and sensor data about their activities in the field. From the video and sensor data collected by DeerCam, wildlife researchers will be able to extract a wealth of sciatic data for studying the behavior patterns of wildlife species and understanding the dynamic of wildlife systems.

In this dissertation, we focus on the following four tightly coupled research issues:

(1) Energy minimization. Video compression is computationally intensive and energy-consuming. However, portable video communication devices for mobile video monitoring, especially those in wildlife monitoring and environmental tracking, are often small in size and light in weight. They have limited energy supply for data processing. One of the central challenging issues in portable video communication system design is to minimize the energy consumption of video compression so as to extend the operational lifetime of devices. In this research, we develop joint power-rate-distortion (P-R-D) methods and algorithms for complexity control and energy minimization of portable video encoders. We demonstrate that, given a video encoder, which has already been fully optimized using existing software and hardware techniques, we can further reduce its energy consumption significantly using P-R-D.

(2) Intelligent resource allocation and utility maximization. The objective of video-based wildlife monitoring is to collect important visual information about animalsâ€™ activities in the field for behavior modÂ¬eling and other wildlife research tasks. Therefore, the overall system performance should be measured by the utility of video data collected by the DeerCam system for wildlife research purposes (e.g. behavior modÂ¬eling). In this research, we develop methods to maximize the utility function under resource constraints.

(3) Efficient image encoder. Because of animal motion, the video samples captured by the animal-mounted DeerCam system often suffer from dramatic motion and content change. In this case, a significant amount of video frames and image regions are encoded with the INTRA mode. Furthermore, the image data often has a significant amount of high-frequency structural components, such as trees and grasses. How to develop an image / video compression scheme to efficiently represent and encode structural components becomes an important problem in our research. To address this issue, we explore various approaches, including local structure prediction to efficiently learn, predict, represent, and encode local image structures, super-spatial structure prediction to find an optimal prediction of structure components within the previously encoded image regions, and inter-structure prediction to find an optimal prediction of structure components within the encoded structure components. Our extensive experimental results demonstrate that the proposed methods are very competitive and even outperform the state-of-the-art image compression methods.

(4) Animal interaction detection for event-driven wildlife monitoring. The inter- and intra-specific interaction of wildlife animals is one of the most interesting activities to wildlife researchers. Video accounts of interactions could aid in disease transmission modeling by revealing the frequency and nature of contacts between animals. Many wildlife diseases, such as chronic wasting disease (CWD), have been a central challenge to wildlife managers. Therefore, we develop an animal interaction detection method using supervised learning methods. By integrating this detection functionality into our DeerCam, it is able to

detect events of animal interactions which will trigger the on-board video encoding system to encode video samples. This will significantly reduce the amount of video data to be encoded and improve the utility of the visual sensing data. It will also provide important reference for sub-sequent wildlife behavior analysis.