Understanding Animal Flight with Three-dimensional and Infrared Computer Vision

Invited Keynote Talk

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ABSTRACT

Analysis of bird and bat flight with computer vision algorithms provides a new perspective on how animals move through three-dimensional space. This is important for understanding the intricacies of flight and the interactions of airborne animals that fly in groups. Results can be applied to a large array of tasks, for example, bio-inspired engineering of airplanes [3] and censusing of populations of bats [1], [2], [6].

Censusing populations of bats is imperative for quantifying the ecological and economic impact of these animals on terrestrial ecosystems [5]. Colonies of Brazilian free-tailed bats are of particular interest because they represent some of the largest aggregations of mammals known to mankind. It is challenging to census these bats accurately, since they emerge in large numbers at night from their day-time roosting sites. We have used infrared thermal cameras to record Brazilian free-tailed bats in California, Massachusetts, New Mexico, and Texas, and developed automated image analysis methods that detect, track, and count emerging bats [1].

We have developed guidelines of camera setup and calibration procedures in the field [7]. Our computer vision algorithms use stereography to analyze the three-dimensional flight paths of bats and birds. Our techniques include detection of individual animals in each camera view, reconstruction of their positions in three-dimensional space, across-time and across-space data association, and multiple-object tracking [3], [8]-[11].

We found that six colonies of Brazilian free-tailed bats in the southwestern United States may have plummeted from 54 million members to 4 million since 1957 [2]. Analysis of emergence flights from dusk through darkness also revealed patterns in group behavior. Flow patterns of bats during emergence flights exhibited characteristic single or multiple episodes. A consistent rhythmic pattern of flow episodes and pauses was revealed across colonies and was independent of emergence tempo.

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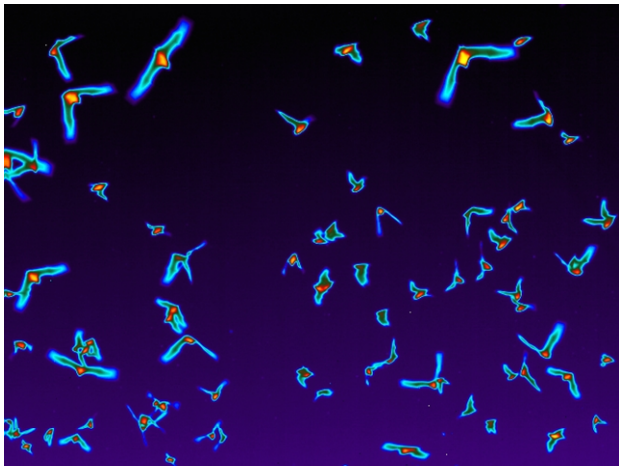

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**] Video, I.2.10 [**Vision and Scene Understanding**] (I.4.8, I.5) 3D/stereo scene analysis, modeling and recovery of physical attributes, motion, video analysis.

General Terms

Algorithms, Measurement, Experimentation

Keywords

Video analysis of animals, multi-view multi-object tracking, animal behavior, group behavior

BIOGRAPHY

Margrit Betke is a Professor of Computer Science at Boston University, where she co-leads the Image and Video Computing Research Group. She conducts research in computer vision, in particular, the development of methods for detection, segmentation, registration, and tracking of objects in visible-light, infrared, and x-ray image data. She has worked on gesture, vehicle, and animal tracking, video-based human-computer interfaces, statistical object recognition, and medical imaging analysis. She has published over 100 original research papers. She earned her Ph.D. degree in Computer Science and Electrical Engineering at the Massachusetts Institute

of Technology in 1995. Prof. Betke has received the National Science Foundation Faculty Early Career Development Award in 2001 for developing "Video-based Interfaces for People with Severe Disabilities." She co-invented the "Camera Mouse," an assistive technology used worldwide by children and adults with severe motion impairments. While she was a Research Scientist at the Massachusetts General Hospital and Harvard Medical School, she co-developed the first patented algorithms for detecting and measuring pulmonary nodule growth in computed tomography. She was one of two academic honorees of the "Top 10 Women to Watch in New England Award" by Mass High Tech in 2005. She is a Senior Member of the ACM and IEEE. She currently leads a 5-year research program to develop intelligent tracking systems that reason about group behavior of people, bats, birds, and cells.

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