Multi-View Tracking of Flocking Birds for 3D Flight Path Analysis in Turbulent Conditions

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Recent studies show that birds can harness energy from turbulent atmospheric flows, such as strong intermittent gusts, whereas small and slow-moving unmanned aerial vehicles are particularly vulnerable to these conditions. This contrast naturally raises the question of how birds achieve this stability and efficiency, and whether similar strategies can be adapted for unmanned aerial vehicles. Considerable research is underway studying interactions between various bird flight modes—gliding, flapping, and soaring—and their responses to turbulence. Many of these studies employ optical methods using multi-camera setups to obtain flight trajectories of individual and flocking birds. In a similar attempt, we plan to study the aerodynamic response of American crows (Corvus brachyrhynchos) to turbulence through stereoscopic field measurements. American crows are among the most intelligent animals, and although many of their behaviors have been widely studied, their ability to extract energy from random gusts remains an open question. We aim to address this gap using precise stereoscopic techniques to quantify their flight responses. Auburn, New York, offers an ideal research site, as American crows exhibit abundant roosting activities within a concentrated 1.5-mile radius during winter months. The present study establishes a pipeline to extract 3D trajectories of flying birds like crows from stereoscopic field measurements. For preliminary analysis, we recorded crow roosting activities around Syracuse, NY, using two Canon R6 Mark II cameras equipped with 50 mm focal-length lenses. Our workflow addresses the multi-camera multi-object tracking (MCMOT) problem through several distinct stages, beginning with single-view object tracking. This stage involves two sub-processes: object detection—identifying birds individually within video frames—and object tracking, where these identified birds are tracked across successive frames. Background subtraction techniques currently yield superior performance among various detection methods by effectively isolating birds in motion from static backgrounds, thus simplifying subsequent tracking tasks. Once individual detections are established, these must be tracked consistently across multiple views. We achieved optimal 2D tracking results thus far using DeepSORT, a machine learning-based tracking algorithm employing a Kalman filter approach. This algorithm performs well under normal circumstances but can struggle when tracked objects exhibit sudden or abrupt changes in their flight path, leading to high accelerations. As a part of future work, we intend to study the performance of different position filters to improve tracking results in such conditions. Another future direction involves addressing occlusions during background subtraction, where multiple birds might appear as a single detection due to overlapping. Additionally, obtaining accurate extrinsic calibration parameters for the stereoscopic camera setup remains critical. Therefore, robust extrinsic calibration protocols are developed for each recording session. These protocols involve flying a wand-mounted UAV across the cameras' field of view. Subsequently, wand end-points along with selected background reference points are digitized using DLTdv8 software and then processed using EasyWand or MATLAB's Computer Vision Toolbox to perform bundle adjustment calibrations. Currently, our efforts are focused on integrating different camera views using the extrinsic calibrations to enable comprehensive multi-object tracking across views. This integration will facilitate calculation of crucial kinematic variables, including velocities, accelerations and their differences, providing deeper insights into avian flight dynamics under turbulent conditions.

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