Combining Deep Learning With Optical Flow Methods For UAV-To-UAV Tracking

Jakub Karbowski, AGH University of Science and Technology, Krakow, Poland

Abstract

Recent trends in computer vision (CV) show the pursuit of large-scale neural networks for object detection. Research has shown that these models achieve better results [1]. Current state-of-the-art methods need substantially more training data or augmentations to prevent overfitting [2]. This makes them impractical for niche domains where curated datasets are uncommon.

This work describes a CV system for detection and tracking of Unmanned Aerial Vehicles (UAVs), that combines classic and deep learning methods. The system is designed to operate on Edge-AI devices mounted on UAVs.

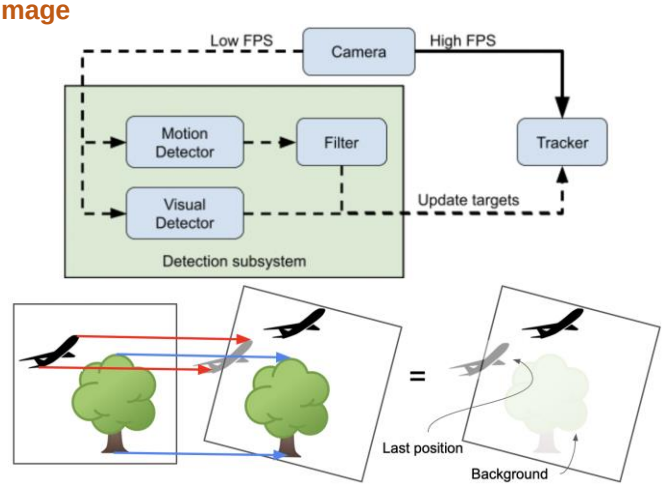
Aside from visual characteristics, spatio-temporal features such as motion can be used for object detection [3]. Video-aware neural networks have been developed for the purpose of motion detection [4]. However, classic algorithms exist for such tasks and offer better performance [5].

The developed algorithm solves two edge cases in object detection: when objects are visually unrecognizable and when the scene is stationary. It does this by using both appearance and motion, focusing on one when the other is limited. It consists of two subsystems: detection and tracking. The detection subsystem uses appearance and motion to pinpoint objects of interest. Tracking works between detection events, increasing framerate.

Motion is detected by computing point-to-point correspondences between subsequent frames with the Lucas-Kanade optical flow algorithm. A background motion model is estimated with the RANSAC method to detect outliers based on velocity vectors. Background subtraction is used to mask stationary areas. A neural network for object detection is used when motion is unavailable. It operates on cropped regions of interest given by previous detections to improve performance and increase resolution.

The result is a real-time UAV-To-UAV tracking system that can be used with limited training data. The solution has been tested in real-world scenarios on actual UAVs. The performance has been evaluated on existing and custom datasets.

Image



Recent Publications

1. Wenhai Wang et al. (2022), InternImage: Exploring Large-Scale Vision Foundation Models with Deformable Convolutions, https://doi.org/10.48550/arXiv.2211.05778
2. Golnaz Ghiasi et al. (2021), Simple Copy-Paste is a Strong Data Augmentation Method for Instance Segmentation, https://doi.org/10.48550/arXiv.2012.07177
3. Bhunesh Patel et al. (2018), Motion based Object Tracking, International Journal of Electronics, Electrical and Computational System, IJEECS, ISSN 2348-117X, Volume 7, Issue 4, 581-588
4. Yukun Su et al. (2022), A Unified Transformer Framework for Group-based Segmentation: Co-Segmentation, Co-Saliency Detection and Video Salient Object Detection, https://doi.org/10.48550/arXiv.2203.04708
5. Li Jing (2019), Fast and Robust UAV to UAV Detection and Tracking Algorithm, PhD Thesis, Purdue University, West Lafayette, IN

Photograph



Biography

Jakub Karbowski is a computer science student at the AGH University of Science and Technology. Professionally, he works with natural language processing and AI. He is active in the AGH Drone Engineering science club, where he develops computer vision algorithms and drone control systems. He has a passion for embedded hardware and software, as well as electronics and robotics.

Email: carbon@student.agh.edu.pl