

Glint De-Noising for Wing-in-Ground-Effect Craft Altimetry

Motivation

Modern maritime aviation is seeing a shift toward high-speed, above-water vehicles that utilize Wing-in-Ground (WIG) effect technology. These craft operate within one wingspan of the water's surface, skimming just meters above the water to maximize aerodynamic efficiency. To achieve such performance, accurate altitude estimates are critical in ensuring reliability, safety, and control margins.

In my professional work with REGENT, I see these challenges firsthand through the development of the Viceroy, an all-electric seaglider. The Viceroy transitions between float, foil, and fly modes, eventually reaching speeds of over 100 mph while maintaining an altitude of only 5 to 30 feet above wave peaks.

Current vision-based altimetry for maritime environments is hampered by sun and sky glints—non-linear, non-stationary signals that obscure the water's texture and reduce the signal-to-noise ratio (SNR) for feature tracking. This project proposes a computational imaging pipeline that uses signal decomposition to remove glint noise, providing the clean "residual" imagery necessary for a high-precision neural altimeter.

Project Goal & Related Work

The goal is to develop a robust image-based altimetry pipeline that can estimate a wing-in-ground effect vehicle's height above the instantaneous surface level (waves) and the mean sea level.

Lee, et al propose a glint-suppression method to isolate and remove the periodic high frequency sun glint components and extract a cleaner residual image for use in perception algorithms [1]. After the image is cleaned, classic inverse perspective mapping can be applied to the camera image to estimate height (or distance) based on a monocular image, as discussed by Mao, et al [2]. As an alternative, I can also consider stereo-based depth estimation, which has the advantage of being robust to ground speed variation. Moore, et al present a novel stereo camera-mirror based system to project the images into a cylindrical coordinate system to gain depth estimation purely on imagery [3]. While simulating such a complex camera setup is infeasible for this project, it does provide insight into the types of rectification algorithms that could benefit from a stereo vision-based solution.

After obtaining the the "clean" and rectified images, I can leverage a trained CNN-based image regressor, like RESNET or similar, to help predict altitude based on training data with labels.

Training such a dataset using physical hardware is infeasible for this project, but leveraging artificially generated data via Unreal Engine, FlightGear, or publicly available data from UAV or drone capture is a reasonable alternative.

Milestones and Timeline

- Week 1 (Week of Feb 23rd): Data collection and preprocessing. Utilize the Mavic Nadir Imagery Dataset or synthetic data from FlightGear to establish a baseline.
- Week 2 (Week of Mar 2nd): Implementation of the glint removal model. Benchmark performance by comparing PSNR before and after decomposition.
- Week 3 (Mar 9th): Integration of height estimation regression model. Final analysis and report generation.

Sources

- [1] Lee, J.-S., et al. (2025): "A Novel Method for Eliminating Glint in Water-Leaving Radiance from UAV Multispectral Imagery."
- [2] Mao, J. & Zhang, L. (2025): "Basic theories and methods of target's height and distance measurement based on monocular vision."
- [3] Moore, R. J. D., et al. (2020): "UAV Altitude and Attitude Stabilisation using a Coaxial Stereo Vision System."