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UTC Spotlight

University Transportation Centers Program

This month: West Virginia University | February 2012

Development of UAV-Based Remote Sensing Capabilities for Highway Applications

Researchers from West Virginia University (WVU) have successfully demonstrated that a low-cost, remotely controlled (R/C) aircraft can provide a stable aerial platform with the potential to aid transportation professionals in a variety of research and applied uses. The small unmanned air vehicle (UAV) acquires high-resolution images that could be used in work zone management, traffic congestion, safety, and environmental impact studies. Compared to fixed-position ground sensors, airborne sensors offer mobility and measurements from multiple perspectives. Additionally, UAVs can be used to perform missions within hazardous environments without endangering the operators.


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Figure 1. Students Working on the WVU Phastball-0 Aircraft

Aerial Data Acquisition Platform

A remotely controlled aircraft, named '*Phastball-0*', was custom developed at WVU for remote sensing for highway applications. The airframe features a modular composite construction with most components manufactured in house by WVU undergraduate and graduate students. The aircraft has a 96-inch wingspan and a takeoff weight of 21 lb, including 7 lb of remote-sensing payload. The aircraft is remotely piloted with a 9-channel R/C radio system and is powered with a pair of brushless electric ducted fans. The use of an electric propulsion system simplifies the flight operations and reduces the amount of vibrations on the on-board sensors. Figure 1 shows a group of WVU students working on the '*Phastball-0*' aircraft at the airfield.

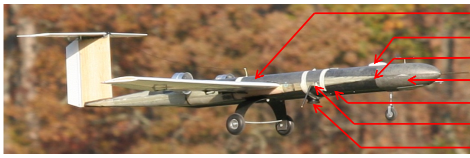

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Figure 2. Aircraft Instrumentation for Remote Sensing

The main components of the remote-sensing payload system include a high-resolution digital still camera (either in the visible spectrum or near infrared), a 50 Hz GPS receiver, a low-cost Inertial Navigation System (INS), a 400-yard down-looking laser range finder, a flight data recorder, a video camera and a wireless video transmission system. The custom-designed flight data recorder allows for full control of the sensor selection, sampling rate, data quality, and time synchronization. The wireless video system serves primarily as a viewfinder for assisting the ground crew in determining an area of interest before taking a sequence of still images. An extensive calibration and analysis effort for major measurement instruments was performed to ensure that flight data are properly calibrated and time aligned. Additionally, an Unscented Kalman Filter (UKF) based 15-state GPS/INS sensor fusion algorithm was developed to reduce noises in the GPS measurements and to estimate the aircraft attitude angles in flight. The location of each on-board sensor on the aircraft is shown in figure 2.

Geo-Referencing

Geo-referencing software was developed by the research team to measure distances to an aerial image and

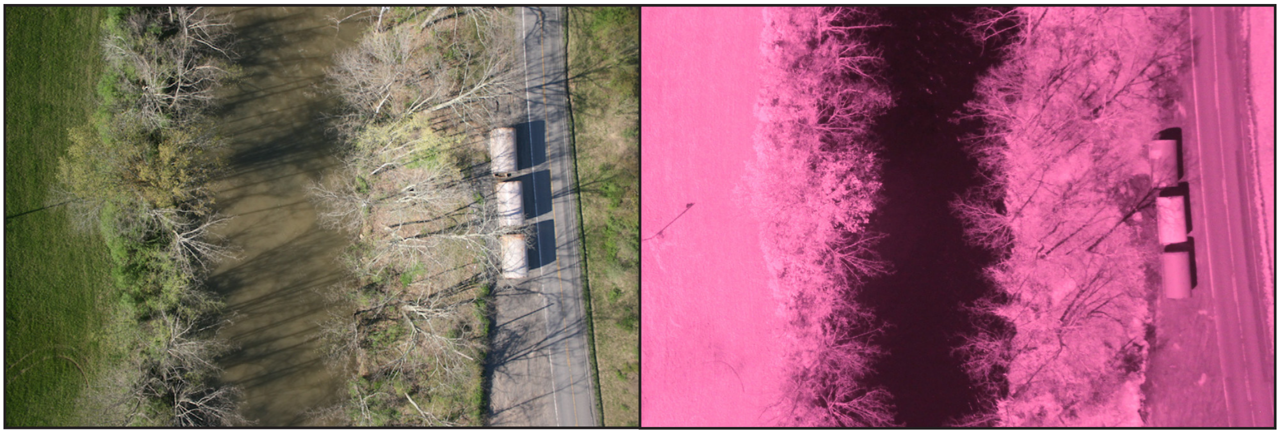

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Figure 3. Aerial Photos of the Same Region With Visible Spectrum and Near-IR

estimate the geo-location of each ground asset of interest. A comprehensive study of potential geo-referencing sources of errors identified factors that might affect the position estimation accuracy.

A number of flight test experiments were conducted to evaluate the functionality and performance of the remote sensing system. Figure 3 shows two collected images of the same general region with both visible and near-IR wavelengths.

The geo-referencing performance was evaluated using a set of flight data and the known location of a fixed reference point on the ground. The flight data analysis shows an approximately 7.2-meter mean position estimation error was achieved with estimates from a single aerial image, after a set of lens distortion and camera orientation corrections. Furthermore, a 0.5-meter position estimation error was achieved with an averaging of 15 individual estimates. The geo-referencing performance for one of the flight experiments is illustrated in figure 4.

This study successfully demonstrated that a low-cost aerial platform, with a proper calibration and fusion of sensory data, can achieve a high level of geo-referencing performance. This project also provides opportunities for five graduate students and one undergraduate student to perform hands-on research and to increase their exposure to the latest technology in sensors, electronics, image processing, sensor fusion, software development, and flight-testing.

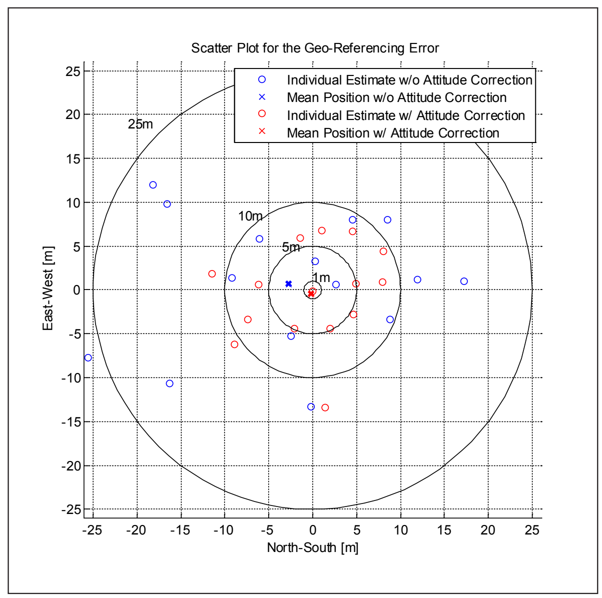

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Figure 4. Distribution of Position Estimates With and Without Attitude Corrections

About This Project

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