Multiple Micro Aerial Vehicles for Applications in Remote Sensing

Christopher J. Hall, Daniel Morgan, Austin M. Jensen, Haiyang Chao, Dr. YangQuan Chen, and Dr. Mac McKee
Utah Water Research Laboratory, Center for Self-Organizing and Intelligent Systems (CSOIS), Utah State University

Contact: yangquan.chen@usu.edu

Project Web: http://www.engr.usu.edu/wiki/index.php/OSAM

ABSTRACT:
Micro Aerial Vehicles (MAVs) are miniature unmanned aircrafts that can be equipped with cameras for applications in real-time remote sensing. MAVs have many potential environmental research applications including water and air quality monitoring, fish tracking, lake current monitoring, agricultural spraying, flood recovery monitoring, weather forecasting, patrolling wetlands, crop monitoring, and many more. For example, farmers using MAVs equipped with both near infrared and standard NTSC cameras can monitor their crops via the created Normalized Difference Vegetation Index (NDVI) images which are indicative to regions of the crops under water stress. In this way irrigation demands can be forecasted approximately a week in advance. Advantages of using MAVs relative to manned aircraft or satellite remote sensing systems are that MAVs have high spatial resolution, low temporal resolution, and are low-cost, yet can still incorporate multi-spectral imagery, with accurate sensor data, and real-time data acquisition and processing. In order to achieve low-cost we have used a model aircraft parts from the remote control airplane industry with the Paparazzi open-source autopilot. By using an inertial measurement unit with a Kalman filter the roll, pitch, yaw, altitude, geographic coordinates, and velocity of the aircraft are accurately measured. This data along with the aerial images are transmitted to a ground control system in real-time which automatically uses sensor information to further process the images creating a set of standardized pictures which are valuable for remote sensing. These images can then be “stitched” together to create a single high-resolution picture covering a large area. By using an automated system over man-in-the-loop systems more consistent and accurate results are achieved. Further optimization is made by using multiple MAVs working collaboratively, which facilitates large area coverage in short amounts of time, ultimately resulting in less man hours spent at the ground control system.

Why Manage Irrigation?
Irrigation is important, because it is a large water user and inefficient. According to Professor Mac McKee, “In Utah, diversions for irrigated agriculture represent approximately 85 percent of the state’s water use.”

Why UAVs (not Simply Satellites?)
• Lower cost remote sensing
• Higher spatial resolution (sub-meter resolution)
• Good timing

Stitched Image Applications
• Precision Agriculture Applications
• Military Reconnaissance
• Traffic Monitoring
• River Tracking
• Map Updating

Spectrum Analysis For Irrigation
1. Gather vision images
2. Gather near infrared images
3. Interpolate red and near infrared images to calculate the Normalized Difference Vegetation Index (NDVI)
4. NDVI is used to measure of water saturation in crops
5. Merge collected data with satellite data and on-ground sensors
6. Use to create a 7 day forecast of crop irrigation needs

Imagery
Our system delivers images in the several spectra
• Vision (blue, green, and red spectra)
• Near Infrared
• Thermal Infrared

Real-Time Processing Provides
• Low resolution .3 megapixel images delivered while in-flight
• High resolution 8 megapixel images delivered post-flight

References

Acknowledgements
This work has been funded by the Utah Water Research Lab, the Center for Self-Organizing and Intelligent Systems, the National Science Foundation REU program, and USU Undergraduate Research and Creative Opportunity Grant. Special thanks to the UAV team at CSOIS for their contributions to this project.