Small Unmanned Aircraft Systems (sUAS) Technology and Applications in Agriculture

David Burchfield
Applied Research Associate, RoboFlight Systems, LLC
EDUCATIONAL BACKGROUND

Brigham Young University, Provo, UT
- Bachelor of Science (2011)
- Department of Geography
- Emphases: Geographic Information Systems (GIS) and Remote Sensing

Kansas State University, Manhattan, KS
- Master of Arts (2014)
- Department of Geography
- Emphases: GIS, Remote Sensing, Unmanned Aircraft Systems
- Graduate Advisor: Dr. Kevin Price

Thesis: Mapping Eastern Redcedar (*Juniperus virginiana* L.) and Quantifying its Biomass in Riley County, Kansas
Students and faculty at KSU enjoyed conducting research with sUAS, commonly referred to as Unmanned Aircraft Vehicles (UAVs) or drones.

**Graduate Research Assistants**

- Nan An (Ph.D. Student, Agronomy)
- Ray Asebedo (Ph.D. Student, Agronomy)
- Lynn Brien (Ph.D. Student, Geography)
- David Burchfield (M.A. Student, Geography)
- Johnny Bryant (M.A. Student, Geography)
- Atena Haghighattalab (Ph.D. Student, Geography)
- Dwayne Rice (M.S. Student, Agronomy)
- Carter Wang (Ph.D. Student, Geography)
- Huan Wang (Ph.D. Student, Agronomy)
- Elle Williams (M.A. Student, Geography)

Dr. Deon van der Merwe and Dr. Kevin Price demonstrating autonomous flight to the news media in July of 2013.
ECONOMIC IMPACT OF UAS

• More $13.6 billion in the first three years
• $82.1 billion between 2015 and 2025
• More than 34,000 manufacturing jobs
• More than 70,000 new jobs in the first three years
• An anticipated 103,776 new jobs by 2025
• Tax revenue to the states exceeding $482 million in the first 11 years following integration (2015-2025)
• Every year that integration is delayed, the United States loses more than $10 billion or $27.6 million per day that UAS are not integrated into the NAS.
• The majority of UAS will be used in the agricultural industry

Statistics per Association of Unmanned Vehicle Systems International (AUVSI) 2013 Report
Basic Principles of Remote Sensing

Natural color image of soybean

Healthy

Unhealthy
BASIC PRINCIPLES OF REMOTE SENSING

Examples of blue, green, red and near infrared (NIR) wavelength images.

NIR cannot be seen with our eyes, but it can be detected with sensors.
Creating a Normalized Difference Vegetation Index (NDVI)

Red Wavelength = NIR

NDVI
NIR, red and green false color composite

NDVI with red = high values, blue = low values
ADVANTAGES OF AN AERIAL PERSPECTIVE

What a farmer, crop scout or insurance adjuster sees from outside the corn field.

What a farmer, crop scout, or insurance adjuster sees from within the corn field.

Irrigated corn near Garden City, Kansas
Map quality image products that allow agronomists and farmers to identify problem areas in their fields, such as diseases, insect infestations, nutrient deficiencies, and water stress. These images can also be used to identify areas where replanting is necessary early in the growing season.

The Normalized Difference Vegetation Index (NDVI) is useful for identifying problem areas in fields, often with better contrast than a color infrared image.

NDVI is used to create management zones into which different treatments will be applied. The Shapefile format is compatible with most farm management software packages.

**Spatial Resolution (Pixel Size):**
- 10 inches

**File Format:**
- GeoJPEG/GeoTIFF

**Output Products:**
- Natural Color (Red, Green, Blue) or Color Infrared (Near-Infrared, Green, Blue) Image

**Spatial Resolution (Pixel Size):**
- 10 inches

**File Format:**
- GeoJPEG/GeoTIFF

**Output Products:**
- NDVI Image (Single Band)

**Spatial Resolution (Pixel Size):**
- 10 inches

**File Format:**
- Shapefile

**Output Products:**
- NDVI Management Zones in Shapefile Format
UNMANNED AIRCRAFT SYSTEMS

- Aircraft (Fixed Wing and Multirotor)
- Cameras (Visible, NIR, Thermal, Multispectral, Hyperspectral)

Multirotor systems are appropriate for small scale and research operations under 10 acres.
Disadvantage of multirotors: you cannot cover large areas (a few acres per flight)

Advantage of multirotors: you can have a gimbal and can carry a heavier payload
RoboFlight’s RF70 Fixed Wing Aircraft
RoboFlight RF-70: A True Aerial Mapping System
MANNED AIRCRAFT

Our company is committed to collecting and processing quality remotely-sensed data, whether it be from unmanned aircraft, manned aircraft, or satellites.

Cessna pod camera mount

Aerial imagery collection with a Cessna aircraft
WHY BOTHER WITH DRONES WHEN WE HAVE SATELLITES?

• Very high temporal resolution (repeat frequency) (vs. 16 days for Landsat 8 imagery)

• Can collect data more easily between cloudy periods

• Spatial resolution (pixel size) (30 meters for Landsat 8 vs. down to 1 cm for UAS)

• Cost may be less ($640 for a scene of 6.5-meter RapidEye imagery vs. ≈ $2-4/acre for UAS)
Landsat 8 Imagery
Study Field in SW Colorado
Color Infrared Image Comparisons (Landsat 8 vs. Cessna)

June 23, 2014

Landsat 8 (98 foot pixels) (30 m pixels)

NDVI Values
- Low
- Med
- High

June 26, 2014

Cessna (10.0 inch pixels) (25 cm pixels)
Subset area for demonstration
Farmers using precision agriculture CRAVE this level of detail.
Winter Wheat (UAS vs Cessna vs Satellite)

1.0 inch pixels
- Color infrared
- NDVI

10.0 inch pixels
- Color infrared
- NDVI

5.0 m pixels
- Color infrared
- NDVI

Low NDVI

High NDVI
Selected Applications of Aerial Imagery in Agriculture and Natural Resources
TOMATO STAND COUNT IN NORTHERN CALIFORNIA
Tomatoes
Crop Density Assessment

Within the accuracy assessment areas:
2,335 plants delineated
**10.5%** less than capacity
Using sUAS Imagery and AgPixel to Model Corn Yields

- Color Infrared Mosaic of Corn Field
- Yield Map
- Sandy Soils

Lower Yields

- T4i green-NDVI vs. Corn grain yield
  \[ y = 7.8986x - 823.77 \]
  \[ r^2 = 0.91 \]

- T4i red-NDVI vs. Corn grain yield
  \[ y = 6.2546x - 607.85 \]
  \[ r^2 = 0.90 \]

Higher Yields
WEED MANAGEMENT

We are partnering with Crop Quest to develop methods for delineating weed patches in crop fields.
WEED MANAGEMENT

• Orthomosaic showing the distribution of Canada Thistle across the entire field

• The producer sprayed the entire 120-acre field, when only 0.6 acres were covered by weeds
OUR DATA FEED INTO VARIOUS FARM MANAGEMENT SOFTWARE PACKAGES
Canada geese have damaged about 12% of the acreage on this 188 acre field.
RANGE MANAGEMENT APPLICATIONS

Rannells Tallgrass Prairie Preserve
Grazed Tallgrass Prairie

Ungrazed Tallgrass Prairie

Canon T4i Camera (5 m)

$y = 4E-07e^{0.1251x}$

$r^2 = 0.96$
EASTERN REDCEDAR MAPPING AND BIOMASS QUANTIFICATION
Multi-date Supervised (SVM) Classification
Riley County, Kansas, 2011

Agricultural Land
Deciduous Forest
Rangeland
Eastern Redcedar
Urban
Water
Wetland

Eastern Redcedar Producer (Omission) Accuracy: 93%
Eastern Redcedar User (Commission) Accuracy: 100%
Overall Classification Accuracy: 81%
Total Area of Eastern Redcedar Cover: 6,269 acres

Classification and Cartography by David Burchfield
Contributors: Johnny Bryant, Kevin Price, Larry Biles, Ross Hauck
Ritewing Zephyr II (custom-built by Deon van der Merwe)
LDP LLC – modified Canon Powershot S100 NDVI Camera
GoPro HD Hero3 Video Camera
Ardupilot Mega 2.5 Autopilot
Eastern Redcedar Canopy Area versus Biomass

Some data from Strauss, et al. (2011)

\[ y = 17.10x - 36.47 \]
\[ r^2 = 0.90 \]
THE BOTTOM LINE

• UAS technology gives users quick access to high-resolution aerial imagery.

• There is a multitude of applications in the agriculture and natural resources management sectors.

• The cost of sUAS imagery is declining as the technology becomes widely available.

• Regulations surrounding the use of UAS and the inefficiency of collecting data with a UAS over large areas may necessitate data acquisition using manned aircraft. Satellite imagery also has an important place in analysis of large areas.
David Burchfield

Applied Research Associate
Research & Technology Development
RoboFlight Systems, LLC

david@roboflight.com
515-777-7704