sUAS for Mapping and Monitoring Smallholder Farms in Tanzania

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AgriSense Africa

- Part of an international initiative to explore ways to use remote sensing technology to improve agricultural practices in Sub-Saharan Africa and South Asia.
- The project aims to use Remote Sensing Technologies to:
  - Improve agricultural monitoring
  - Improve food security forecasting
UAVs are being explored to
- Linking the Ground and Space-borne data
- Use in lieu of remote sensing data
Study Area

- UAV data collected at Tanzanian sites only
- Data collection started in March (pilot stage)
- Monthly repeat coverage of 1km² area
- Sites have been chosen to represent the agricultural productivity gradient in Tanzania
  - Same: Low
  - Kilosa: Medium
  - Njombe: High
- Smallholder, subsistence farming
- Crop boundaries change every season
- Mixed and Intercropping is common
sUAS being Deployed

- Fixed Wing: senseFly eBee
  - Endurance: ~25 to 35 minutes
  - Weight: ~700 grams
  - Sensors
    - Modified canon s110 cameras
    - Custom Multispectral camera

- Multi-rotor: Geo-Konzept x8000
  - Endurance: ~20 minutes
  - Sensors
    - 5 channel Multispectral camera
    - RGB camera (Sony Nex 7)
Sensors for senseFly eBee

RGB camera

NIR camera

MultiSpec 4c

(With onboard calibration data)
Sensors for X-8000

TetraCam 6-Channel Mini MCA

- Spectral Bands
  - Band 1: 550 nm (Green)
  - Band 2: 680 nm (Red)
  - Band 3: 710 nm (Red-Edge)
  - Band 4: 740 nm (Red-Edge)
  - Band 5: 800 nm (NIR)
  - Band 6: Incident Light Sensor (ILS)

- On-board calibration data
Workflow

The objective is to:

- Estimate crop metrics at Management unit level
  - Plot boundary
  - Crop type
  - Crop condition
  - Crop height (may be)
- Multi-temporal spectral and textural pattern library
- Calibration and validation of space-borne crop metric estimation algorithms
Workflow

1. **UAV Images**
2. **Geo-Tagging**
3. **Digital Surface Model** (Structure for Motion)
4. Geometric / Spectral Calibration
5. **Ortho-Mosaic**

**Object Based Image Analysis**
- Segmentation
- Spectral Merging
- Supervised Classification
- Crop Metrics for Management units
Workflow

UAV Images → Geo-Tagging → Digital Surface Model (Structure for Motion) → Geometric / Spectral Calibration → Ortho-Mosaic

Object Based Image Analysis
- Segmentation
- Spectral Merging
- Supervised Classification
- Crop Metrics for Management units
Segmented orthomosaics created using ~500 images from the Cannon S110 camera on board senseFly eBee.
Workflow

1. UAV Images → Geo-Tagging → Digital Surface Model (Structure for Motion) → Geometric / Spectral Calibration → Ortho-Mosaic

- Object Based Image Analysis
  - Segmentation
  - Spectral Merging
  - Supervised Classification
  - Crop Metrics for Management units

- Spectrally Merged segments for identification of active farms

Mbuyuni, Kisesa, Morogoro, Tanzania
Results used to calibrate and validate space-borne crop metric estimation algorithms.
Challenges

- **Equipment problems**
  - eBee multispectral sensor overheats causing autopilot malfunction in sunny Tanzanian afternoon
  - Bird hits, it attracts attacks from territorial birds often (Neusence)

- **Low Endurance**
  - 15 to 30 minutes depending on the wind speeds and camera choice
  - Needs three flight missions to cover a 1x1km area

- **BRDF**
  - Hotspot and specular reflectance is a serious problem when flying close to noon or in windy conditions
  - Difficulty creating stable mosaics

- **Clouds**
  - Change in light conditions caused cloud shadows makes creating radiometrically stable Mosaics quite difficult

- **Low internet bandwidth**
  - Difficult to transfer data from Tanzania to UMD
Lessons Learned

- Building capacity for sUAS operation at local institutions in Tanzania was fairly easy
- However good results still need oversight by a remote sensing expert
  - Evaluate intermediate results in the field
  - Fix problems with the UAV operation protocol and schedule
  - Manage data
- COTS systems, however expensive, still need through testing
  - Need for a test site near UMD
- UMD UAS test site
UMD UAS test site

- Supports every aspect of UAS research
  - Collaborative approach
  - Airspace integration (COA)
  - Airworthiness review
  - Payload Integration and pilots

- Range of UAVs already available for use.
  - Fixed wing systems
    - Endurance range: upto 5 hours
    - Payload capacitie: upto 12 lbs
  - Multi-rotor systems
    - Endurance range: upto 30 min
    - Payload capacitie: upto 3 lbs
Thank You!