Guest: Dr. Keshav Singh

Institution: AAFC

Interview date: 5-11-22

Background

Dr. Singh is a Research Scientist who works for Agriculture and Agri-Food Canada (AAFC) and is stationed in Lethbridge, Alberta. His scientific background is mostly on remote sensing and phenomics. He uses a lot of different measurement techniques in his research program including: imaging and analysis of indoor plant growth experiments, remote sensing using UAS/satellite, and proximal imaging using phenocarts. Roughly 50% of his program is based upon aerial imaging using RGB, thermal, and multispectral sensors.

The main focus crops at his location are wheat, canola, lentils, dry beans, and other pulse crops. Prior to his position at AAFC he did postdoctoral training at the University of Saskatchewan and University of California – Davis.

Interview Questions:

*1.      What do you consider the biggest barriers to entry for implementing a UAS into a research program?*

One of the biggest barriers to entry is system integration. Specifically getting the drone and sensor to communicate effectively. There are very few companies that provide integrated systems that enable the UAS and sensor (multispectral or hyperspectral) to communicate seamlessly. There are several options for both multispectral cameras and UAS. Getting the system made of components from different manufacturers to consistently collect the needed data is a real challenge for someone starting out.

His group has several drones. The two major ones are a DJI M4 and a DJI Matrice 600 Pro. They use a MicaSense multispectral sensor (RedEdge?) and use hyperspectral cameras from Specim and Resonon.

*2. What do you consider to be the most and least promising applications of UAS-based imaging for agricultural research?*

The most promising applications are: measuring plant emergence, assessment of plant vigor, plant maturity, measurement of plant height, and plant foliar biomass.

There is some potential to measure how plants respond to abiotic and biotic stress. Multispectral indices clearly respond when plants are stressed. The key is to understand how these measurements influence final yield or other product quality traits.

Even with multispectral sensors it can be difficult to identify the cause of stress. For example it can be a challenge to identify if plants are suffering from drought or nitrogen stress from UAS image data alone.

Q: Does hyperspectral help?

A: Yes, maybe. Hyperspectral imaging is a promising technology because you have so many bands for classification but the major issues are in how you deconvolute the signal. This is not a trivial issue and more work is needed to know how effective these sensors can be.

*3.      What are some of the things you wish you had known before you began using a UAS for data collection?*

First steps are to have a flight and data collection protocol to follow. Make sure you know how to integrate the system through the series of apps needed to get the hardware to communicate and function correctly. Next you need to know how the sensor should be calibrated. The sensor needs to be calibrated properly for the conditions you are collecting data under. Use of an irradiance sensor (downwelling light sensor) can help adjust light and image exposure.

In some cases, the sensor comes with a calibration target, in other cases you need to be more creative.

There are no off the shelf calibration panels for hyperspectral sensors, but you need to make a selection based upon the sensor range. This is difficult. Calibration tools used in the film industry are typically saturated under the light encountered in field conditions.

They have found the need to develop calibration protocols in the lab. This is particularly important in locations that and different sun angles, etc.

The main objective is to keep data as homogenous as possible.

They have found the most effective calibration panels are usually around 18% reflectivity. Need to consider the calibration and direction of light.

Although the guidance to collect data around solar noon is sound for reducing shadows, this isn’t always possible. Weather patterns differ by region, if there are always adverse weather conditions around solar noon it might be best to collect data earlier or later. The key is to keep the time of flight/data collection consistent. A good rule of thumb is to keep it within 3 hours (+/- 1.5 hours).

*4.      What educational resources have you found most useful when developing your own skillset with UAS-based imaging?*

Probably resources dedicated to decision making of post processing software and the steps needed to get information from the data collected. What is the calibration step? Do you reply upon existing software tools? Do you develop your own processing routine?

It is really important to have a good understanding of computer coding/scripting/programming to analyze the data. Languages that Dr. Singh feels are useful are Python, R, or MATLAB.

He also thinks it is good to have standards to compare data and data analysis routines with. For example: In some cases, for hyperspectral data, there are offsets built into the hardware that will give different values from off the shelf software. It is important to identify if your data falls within the range of expectations instead of just blindly trusting numbers coming out of a software or instrument.

Generally there are 2 types of calibration:

1. Get it from the manufacturer (provided as calibration files)
2. Do the calibration yourself

To generate orthomosaics his team has used both Pix4Dmapper and Agisoft Metahape (nice opensource API), ArcGIS, and they have created custom workflows in Python. Dr. Singh notes that open source tools are nice because it is nice to have the freedom to modify routines.

*5.      Are there other comments you believe would benefit an agricultural researcher considering implementation of a UAS into their research program?*

Good to have groups to share information with on-line. It is nice to share information resources and get feedback in real-time. Open sources is especially useful for public research programs.

Q: Can you talk a bit about the choice of sensor (RGB, multispectral, hyperspectral, LIDAR, etc.)?

A: The choice of sensor is really dependent upon the goals of your program. RGB is mostly used for physical traits. Think of characteristics you can describe with your eyes: Number of plants, size and shape of the plants (3D model etc.). For physiological traits it is generally preferrable to use a multispectral sensor. This can be useful for mapping your field based upon general plant stress. Hyperspectral may give you a deeper understanding of what signal constitutes particular abiotic or biotic stresses. LIDAR gives you more precise height, elevation and volume data. An additional benefit of LIDAR is that it is not depended upon light (data can be collected at night).

Q: What do you use for set up of ground control points (GCPs)?

A: They use a handheld GPS and TRK base unit (Trimble). Some key considerations are that GCPS should be placed at equal distances and cover the entire data collection area. Dr. Singh recommends a minimum of 5. One in each corner of the field and one in the middle. If the field is huge… it might be advisable to use 7 or 8 evenly spaced GCPs.

One option is to use GCP panels that are integrated with GPS. That way you can collect the data at each flight.

Q: How often do you collect ground truth data?

A: Generally the same day as the flight… within 24 hours. They collect data ever time they do a mission.

Q: Where should folks be investing money to make a broader impact?

Goals of folks are different across domains. Researchers are usually focused on papers, studies, etc., whereas industry is focused on direct application, prescription maps, quantity of fertilizer and pesticide application, etc.

The key is how can be we provide this information. One impactful effort would be to train farmers to operate UAS sensors… have a standard pipeline to get the data they need… or hire a team to do this based upon region or commodity.