SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 22

Matching Remote Sensing to Problems

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Remote sensing can provide useful information for a variety of problems. However, there is not a universal solution for all situations because each problem has unique data requirements. Different problems may have different data requirements. For example, the use of remote sensing to scout for pests has a different data requirement than developing an N recommendation. Remote sensing can provide a flexible structure for collecting information that can be analyzed using a variety of approaches. This chapter provides examples of matching remote-sensing information to problems.

Remote-sensing Basics

Remotely sensed images are composed of individual pixels that have a specified spatial resolution. For each information layer (band) that is monitored, a pixel has one value assigned to that spatial location. For a different information layer, a pixel will likely have a different value assigned to it. For example in a healthy plant, the relative pixel value for the blue band might be 7%, whereas in the near infrared (NIR) band, a healthy plant might reflect 60% of the incoming light (Fig. 22.1). An unhealthy plant may have very different reflectance characteristics.

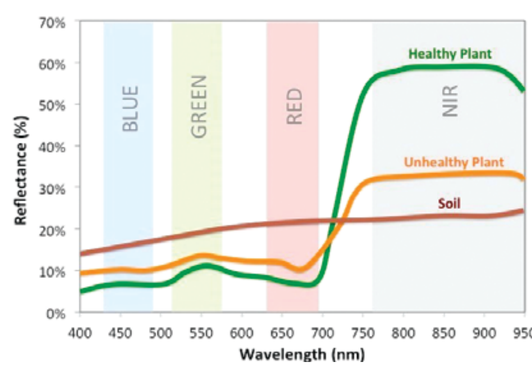

Figure 22.1 Spectral reflectance of healthy plant, unhealthy plant, and soil in visible and NIR wavelengths. (http://www.micasense.com/)

The main advantages of remote sensing are:

1. Rapid analysis (an image can be analyzed in a relatively short period of time).
2. Assessment of a large area within a single image.
3. Easy identification of differences within an image.
4. Improved field scouting efficiency.
5. Up-to-date information.
6. Information from areas difficult to access.
7. Data that can be analyzed using a number of different analysis approaches.
8. Remote data collection.
9. Relatively inexpensive data collection that provides a permanent benchmark.
10. Ability to use sensors aboard a UAV (drone) to overcome problems associated with resolution, rapid

data collection and analysis.
11. Potential ability to convert crop reflectance into variable-rate N application maps.

Disadvantages include:

1. Multiple stresses can have similar impacts on reflectance.
2. Adverse climatic conditions (e.g., clouds and rain) or temporal changes can influence interpretation of findings.
3. Spectral signature of a plant may be different for each plant growth stage.
4. Ground scouting may be required to confirm problem.
5. Different problems may require different spatial resolution (size of each pixel).
6. Pixel values are not acquired by direct measurement.
7. The spatial resolution may be inadequate.
8. Data analysis and collection need trained and experienced person.
9. Geometric and radiometric correction may be required.
10. Image data may be difficult to convert into variable-rate maps.

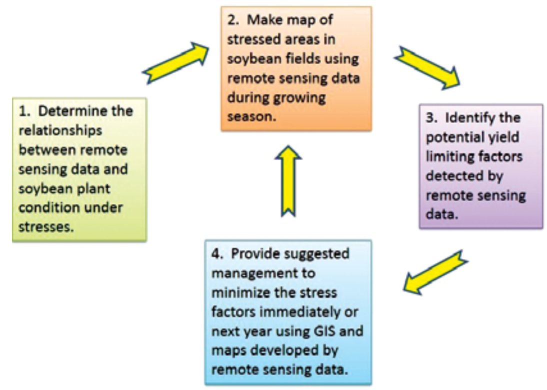

Figure 22.2 The concept of remote-sensing technique for crop management. (Chang et al., 2013)

Application of Remote-sensing Technique to Farming

Application of remote sensing to precision farming can be separated into 4 unique steps (Fig. 22.2): 1) determine whether remote sensing can help, 2) develop a stress map, 3) identify the yield-limiting factors, and 4) develop a corrective management solution.

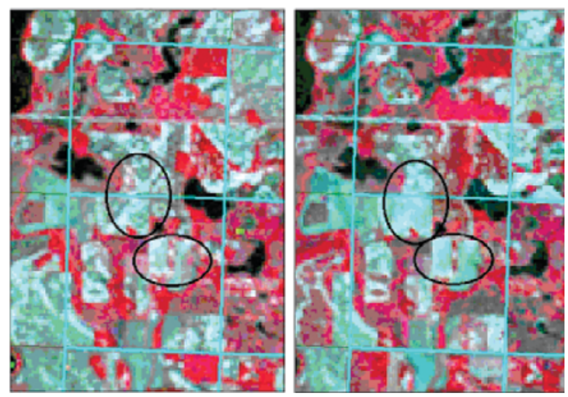

Figure 22.3 Landsat NDVI images before (left) and after a hailstorm (right) The damaged cornfields are within the black circles. (Upper Midwest Aerospace Consortium, umac.org)

Remote-sensing data can be visualized and processed in a variety of ways. For example, a true color composite image can be made by displaying the blue, green, and red bands as blue, green, and red colors, respectively. However, a false color composite image is produced when the green, red, and NIR bands are displayed as blue, green and red colors, respectively. In a true color image, healthy plants appear green whereas in a false color image, a healthy plant appears bright red.

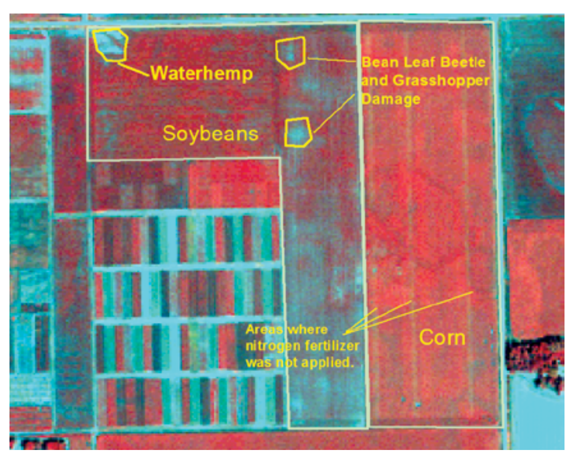

Figure 22.4 False color IKONOS image (green, red, and near infrared) of corn and soybeans collected on July 17, 2002. (Upper Midwest Aerospace Consortium, umac.org)

Images from satellites are useful for identifying problem areas that are not time-sensitive. For example, images of hail-damaged corn fields can be important for crop insurance and for estimating grain yields. Figure 22.3 shows normalized difference vegetation index (NDVI) images derived from Landsat data acquired before and after a hailstorm. The images are useful for identifying the damaged areas and calculating the acreage of the damage.

Grain yields can be reduced by nutrient deficiencies, water stress, weeds, insects, and diseases. Information about the extent of problems can be identified by scouting the field from the air, scouting the field from the ground, or collecting satellite images (Fig. 22.4).

Technical Note for Remote Sensing

Remote-sensing indices have been used for making N fertilizer recommendations. The two most commen indices are NDVI [(NIR – red)/(NIR+red)] and GNDVI [(NIR-Green)/(NIR+Green)]. For NDVI calculations, reflectance in the near infrared and red bands must be collected, whereas reflectance information in the near infrared and green bands must be collected for GNDVI calculations. In some fields, GNDVI has a stronger relationship to N stress than NDVI. Either index can help a farmer switch from a single preplant N recommendation to a split N recommendation, which in turn can reduce fertilizer costs and improve profitability. Across the corn belt, research is being conducted in the development of N management N-based algoriths.

Collecting Remote-sensing Information

Remote-sensing imagery can be collected using various platforms, including handheld, manned aircraft, UAV (Unmanned Aerial Vehicle), and space-based (satellite). Each platform has different advantages and disadvantages (Table 22.1). Understanding the benefits and limitations of various platforms and sensors is critical for selecting the appropriate remote-sensing system. In a general sense, resolution is directly related to cost.

Table 22.1 Advantages and disadvantages of various platforms for remote-sensing data collection.

Platform	Advantages	Disadvantages
Hand or ground	• Can be used to identify the reflectance characteristics of an individual leaf, plant, or area. • Flexible availability. • Useful for real-time spraying applications.	• Collect the reflectance characteristic from a single point, not creating image.
UAV	• Flexible availability. • Relatively low cost. • Very high spatial resolution. • Changeable sensors.	• Relatively unstable platform can create blurred images. • Geographic distortion. • May require certification to operate. • May be limited in height above ground. • Processing the data into field images may be prone to error.
Aircraft	• Relatively flexible availability. • Relatively high spatial resolution. • Changeable sensors.	• High cost. • Availability depends on weather condition.
Satellite	• Some free images. • Clear and stable images. • Large area within each image. • Good historical data.	• High cost for high spatial resolution images. • Clouds may hide ground features. • Fixed schedule. • Data may not be collected at critical times. • May need to sort through many images to obtain useful information.

Ground-based Sensors

Nonimaging portable sensors such as CropScan, Greenseeker, and many others have been used to identify reflectance characteristics for a variety of problems. For example, these sensors have been used to develop a stress index of corn plants and to sense weeds between corn rows. Sensors mounted on a tractor are used for real-time, variable-rate fertilizer/herbicide applications.

Aerial Sensors

Aerial sensors can be mounted on manned and unmanned aerial platforms. The primary advantages of aerial sensors are that the high-resolution images are collected quickly and the data can be used for a variety of problems (Fig 22.4). However, the cost can be very high.

It may be possible to reduce sample collection costs by using a UAV, commonly known as a drone. UAVs can fly any time and take images under cloudy conditions if there is no rain and the wind is under 25 mph. Currently restrictions are in place to prevent flying UAVs higher than 400 feet above ground level. Drone restrictions, however, are under review. The primary limitations of UAVs are vibrations, unstable attitude (roll, pitch, and yaw), and variable wind speeds and directions.

Space-based Sensors

A wide variety of satellite and sensor choices are available (Table 22.2). In general, each sensor collects data within different wavelength intervals and at different resolutions, and each satellite has different revisit times. The spatial resolution of the panchromatic band (black and white or pan band) is generally higher than the resolution for the multispectral (multi) bands. Spatial resolution is the ground area of each pixel within an image. For example, a resolution of 1.84 m means that the pixel has the dimensions of 1.84 by 1.84 m on the ground. Problems with space-based images are that clouds can prevent data collection, the atmosphere can distort reflectance values, and the platforms may have a long revisit time. The data cost can range from free to high.

Table 22.2 Characteristics of sensors mounted on satellites that can be used for agriculture. Pan represents panchromatic (black and white) images, and resolution is minimum size of one side of square pixel within an image.

	Spatial Resolution (m)		Multi-Spectral Bands	Temporal	Relative Cost
	Pan	*Multi*		*Revisit days*	
High Spatial Resolution Images					
GeoEye-1	0.46	1.84	B, G, R, N	2.1 to 8.3	High
WorldView-1	0.55			1.7 to 5.9	High
WorldView-2	0.52	2.4	B, G, R, N, R-edge, 3 others	1.1 to 3.7	High
WorldView-3	0.34	1.38	B, G, R, N, R-edge, 23 others	1 to 4.5	High
Pleiades-1A	0.5	2	B, G, R, N	Daily	High
Pleiades-1B	0.5	2	B, G, R, N	Daily	High
QuickBird	0.73	2.9	B, G, R, N	1 to 3.5	High
IKONOS	1	4	B, G, R, N	3	High
SPOT-6	1.5	6	B, G, R, N	1 to 5	High
SPOT-7	1.5	6	B, G, R, N	1 to 5	High
RapidEye		5	B, G, R, N, R-edge	1 to 6	High
Moderate Spatial Res. Images					
Sentinel-2		10	B, G, R, N, R-edge, 5 others	5 to 10	Free
SPOT-5	5	10	G, R, N, Shortwave IR	2 to 3	Free
LANDSAT 7 ETM+	15	30	B, G, R, N, 3 others	16	Free
LANDSAT 8 OLI	15	30	B, G, R, N, 6 others	16	Free
B: Blue; G: Green; R: Red; N: NIR; R-edge: Red-edge; IR: Infrared					

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