SUGGESTED SOLUTIONS (ODD)

CHAPTER 15

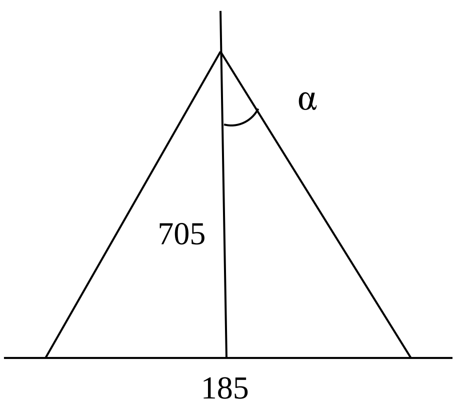
15-1. Landsat 7 travels with a ground speed of 6.47 km/sec in a 705 km altitude circular sun-synchronous orbit. It collects data across a 185 km wide swath (6000 pixels multiplied by a pixel size of 30 meters) which is centered on the nadir track.

A. To perform the whiskbroom scan in the cross-track direction, how large an angle does the mirror scan from nadir?

B. If the FPA for each spectral band is only 16 detectors long, what is the maximum time duration for each cross-track scan, if there are to be no gaps in coverage? Ignore the effects of the scan line corrector mirror.

SUGGESTED SOLUTION:

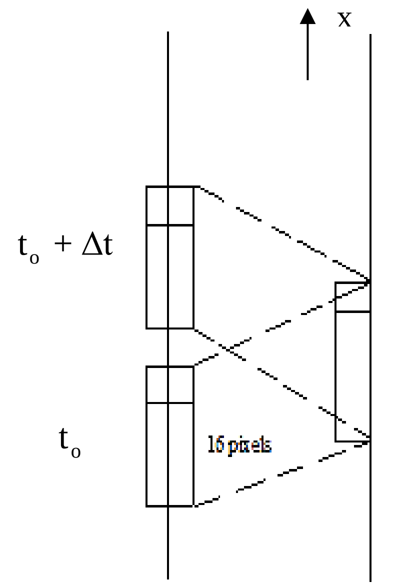
A) Landsat shown below flying into or out of page



$$\tan \alpha = \frac{92.5}{705} = 0.131$$

$$\alpha = 7.47^{\circ}$$

B) Looking down at Landsat swath



Δt must be shorter than time for the satellite to travel a distance = 16 pixels, otherwise, there will be a gap in coverage along the edges of the swath of coverage

$$\Delta x = (16 \text{ pix})(30 \text{ m/pix}) = 480 \text{ m} = 0.48 \text{ km}$$

$$\Delta t < \text{travel time} = \frac{\Delta x}{v} = \frac{0.48\text{km}}{6.47\text{km / sec}} = 7.42 \times 10^{-2}\text{sec} = 74 \text{ msec}$$

15-3. The spectrum from a pixel in a scene P: $\{\lambda_i, P_i\}$ with N bands is compared with a reference spectrum S: $\{\lambda_i, S_i\}$ from a spectral library.

A. Suppose, because of a sensor calibration error, the spectrum P is really P: $\{\lambda_i, P_i - q\}$, where q is a small fixed number.
   1) Does this error affect the angle between P and S?
   2) Does this error affect the vector difference between P and S?

B. Suppose, because of another type of sensor calibration error, the spectrum P is really P: $\{\lambda_i, hP_i\}$, where h is a fixed number.
   1) Does this error affect the angle between P and S?
   2) Does this error affect the vector difference between P and S?

SUGGESTED SOLUTION:

Summary of answers

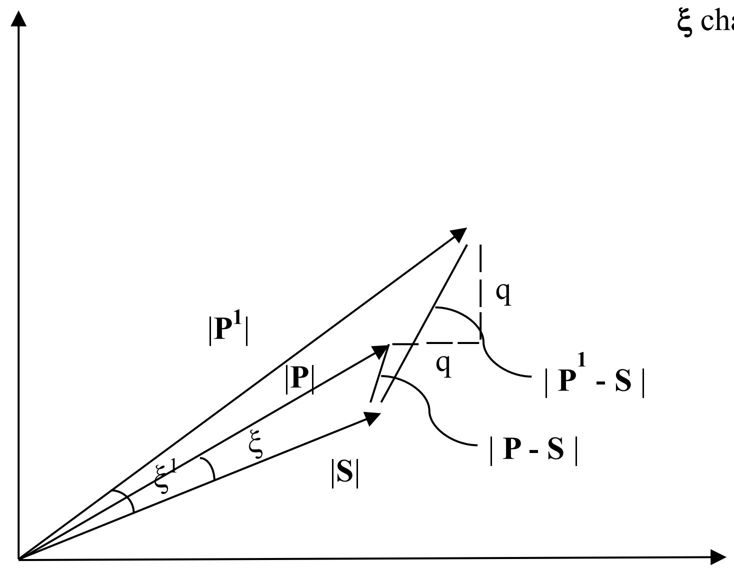
	Spectrum error	Changed vector angle ξ	Changed vector distance **P – S**
A)	$P_i - q$	Yes	Yes
B)	hP_i	No	Yes

Graphical Approach

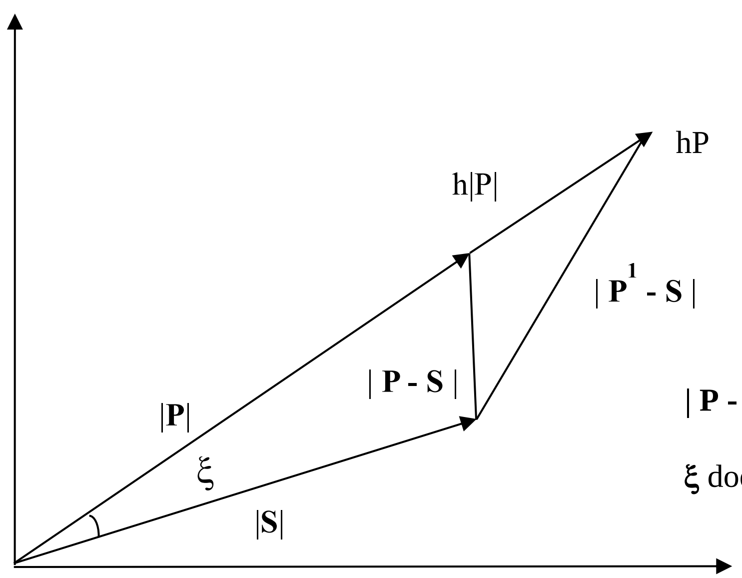
A) $P_i - q$

| **P - S** | changes

ξ changes



B) hP_i



| **P - S** | changes

ξ does not change

Algebraic Approach – spectral angle

Vector angle between $\vec{P}$ and $\vec{S}$, $\theta\left(\vec{P}, \vec{S}\right)$

$$\cos\theta\ (\vec{P}, \vec{S}) = \frac{\sum_i P_i\ S_i}{\sqrt{\sum_i P_i^2}\sqrt{\sum_i S_i^2}}$$

$$= \frac{P_1\ S_1 + P_2\ S_2 + \ldots + P_n S_n}{\sqrt{P_1^2 + P_2^2 + \ldots + P_n^2}\ \sqrt{S_1^2 + S_2^2 + \ldots + S_n^2}}$$

$$\text{A) } \cos\theta\ (\vec{P} - q, \vec{S}) = \frac{\sum_i (P_i - q)\ S_i}{\sqrt{\sum_i P_i^2}\sqrt{\sum_i S_i^2}}$$

$$= \frac{(P_1 - q)\ S_1 + (P_2 - q)\ S_2 + \ldots + (P_n - q)\ S_n}{\sqrt{(P_1 - q)^2 + (P_2 - q)^2 + \ldots + (P_n - q)^2}\ \sqrt{S_1^2 + S_2^2 + \ldots + S_n^2}}$$

$$\theta\ (\vec{P} - q, \vec{S}) \neq \theta\ (\vec{P}, \vec{S})$$

$$\text{B) } \cos\theta\ (h\vec{P}, S) = \frac{\sum_i hP_i\ S_i}{\sqrt{\sum_i (hP_i)^2}\ \sqrt{\sum_i S_i^2}}$$

$$= \frac{\cancel{h}\,(P_1\ S_1 + P_2\ S_2 + \ldots + P_n\ S_n}{\cancel{h}\sqrt{\sum_i P_i^2}\sqrt{\sum_i S_i^2}}$$

$$= \cos\theta\ (\vec{P}, \vec{S})$$

Algebraic approach – Spectral distanceVector Difference

Vector difference $\left|\vec{P} - \vec{S}\right|$

$$\left|\vec{P} - \vec{S}\right|^2 = \sum_i (P_i - S_i)^2$$

$$= (P_1 - S_1)^2 + (P_2 - S_2)^2 + \ldots + (P_n - S_n)^2$$

$$\text{A) } \left|\left(\vec{P} - q\right) - \vec{S}\right|^2 = \sum_i \left[\left(P_i - q\right) - S_i\right]^2$$

$$= (P_1 - q - S_1)^2 + (P_2 - q - S_2) + \ldots + (P_n - q - S_n)^2$$

$$\left|\vec{P} - \vec{S}\right| \neq \left|\left(P - q\right) - \vec{S}\right|$$

$$\text{B) } \left|h\vec{P} - \vec{S}\right|^2 = \sum_i \left[hP_i - S_i\right]^2$$

$$= \left(hP_1 - S_1\right)^2 + \left(hP_2 - S_2\right)^2 + \ldots + \left(hP_n - S_n\right)^2$$

$$\left|\vec{P} - \vec{S}\right| \neq h\left|\vec{P} - \vec{S}\right|$$

15-5. Go to the web site, http://maps.google.com. Navigate to a location of interest (house, work place, church, school, etc).

COMMENTS and OBSERVATIONS:

A. Print a copy of the overhead imagery, and identify the object of interest. Objects need not necessarily be in the US.

B. From the image, what season of the year was the image taken? Are there leaves on the tree, green leaves or red and yellow leaves, snow on the ground,

C. From the image, what time of day was the image taken? If North is to the top of the image (it usually is), what do the location of the shadows suggest?

D. List two pieces of other information that an analyst can determine from the image. Size of the object, layout of the object, unique construction materials (for example. metal roofs), location of roof features (exhausts), relative location of features and other buildings relative to your object of interest.

E. Use the perspective tool, and print two images of your object of interest. The perspective tool involves the "explore" panel (and the little man pictured) below the scaling tool in the image. By dragging him to various locations, imagery for different locations may often be obtained. Obviously, this imagery is quite useful, for example to realtors.