The Effect of Radar Azimuth Angle on Cultural Data

Differences in grey tone within adjacent areas of the Los Angeles urbanized region resulted from angle differences between the radar azimuth and the street pattern and, more importantly, the orientation of the walls of the structures imaged.

Introduction

The study of urban areas from ground, aircraft, and satellite observations is of continuing interest. Land-use studies, based upon data obtained from high altitudes, are proving quite useful for observing the dynamics of urban morphology (change detection) as well as for preparation of land-use maps of more static scenes. Much of the remote sensing work concerning such scenes has dealt primarily with the shorter wavelengths of the electromagnetic (EM) spectrum, i.e., photography (0.4 - 1.5 \( \mu \)m), Landsat (0.5 - 1.1 \( \mu \)m), and infrared, both near (0.7 - 1.5 \( \mu \)m) and thermal (8 - 14 \( \mu \)m). A recent review of the use of Landsat for urban studies is given in Carter et al. (1977).

Generally, for the microwave portion of the EM spectrum, a less detailed effort at data interpretation has been conducted. This is primarily because the passive (radiometer) systems generally have a very low resolution and imagery from the active systems (radars) has been difficult for many investigators to obtain. However, this last constraint has eased considerably in the past several years, and some efforts have been conducted with respect to the interpretation of urban scenes.
from airborne radars. Although Seasat-A (launched on 26 June 1978) failed on 9 October 1978, it had completed about 500 synthetic aperture radar passes of two to ten minutes duration each. With the availability of these data to the scientific community, it is expected that more investigators will show an increased interest in such work.

With respect to the operation, design, and utility of radars for observing, monitoring, and measuring the Earth's surface, several excellent articles are available. Jensen et al. (1977) present an easily readable paper oriented primarily toward discussing the conceptual operation of the radar and including several examples of radar imagery. Brown and Porcello (1969), on the other hand, provide the reader with a more tutorial paper concentrating on an introductory engineering approach to solving the problem of obtaining radar imagery with synthetic aperture systems. Both of these papers provide an excellent background to scientists seeking an introduction to these remote sensing systems.

Several additional papers have shown some of the basic concepts of the interpretation of radar images of urban and other scenes, including Bryan (1974, 1975), Coiner (1971), Henderson (1973), Lewis et al. (1969), and Rosenfeld and Kimberling (1977). Although these papers have dealt with various wavelengths and polarizations, it is noted that, generally, the types of features detectable and the methodology for interpretation remain fairly constant from one radar system to another. There are, however, several variations of the data which can occur within one given (radar) system and, as mentioned, with the advent of the Seasat-A data, some of these variables may be of major importance.

Two of these aspects of the radar system, which are essentially positional or geometrical in their effect on the resulting radar imagery, are the incidence angle and the azimuth angle.

With respect to large geographic and geologic features, especially for radars operating near grazing angles, the areas in shadow on the far side of a feature will be areas of no (surface) information. This does not, however, imply that the shadows themselves do not provide some information for, if the investigator knows some of the operating parameters of the radar (e.g., altitude, depression angle), the height of the feature may be determined from the length of the shadows (LaPrade and Leonardo, 1969). This has been demonstrated by Lewis and Waite (1973) with respect to large topographic elevations in Panama and, for small features (river bluffs), by Bryan and Hall (1976). In urban areas, however, where the elevations of the individual features (e.g., buildings) are generally much less, and especially with respect to the resolution of the radar, such an effort would probably be of minimal utility. Stereo radar also increases considerably the ability to determine height and slope angle, as demonstrated by Leberl (1973), but such data are even less frequent than those from single or multiple look-direction radars. Finally, Coiner and Morain (1971) note for agricultural scenes that there is a '... necessity to account for changes in radar backscatter (grey level shifts) generated by angular dependencies in the scene.' They refer primarily to the depression angle of the radar and not to the azimuth angle, but do alert the interpreter to the fact that the geometry of the scene is of great importance when dealing with radar imagery.

The azimuth angle is defined as the direction, on a plane tangent to the Earth's surface, in which the radar beam is pointed. Thus, although we may refer to the azimuth angle (also sometimes termed the look-angle, look-direction, or by Koopmans (1975) as the scan direction) with respect to the points of the compass, this alone is of little utility. The more important consideration is to determine the azimuth angle with respect to the orientation of the object or target being illuminated by the radar energy. Again, radar interpreters have noted the increased ease with which linear features may be distinguished by orienting the antenna of the radar at slightly different azimuth angles. Generally, this requires an additional aircraft pass for the antenna is, for all practical purposes, securely mounted to the aircraft. Several studies have been conducted to determine the effect of the azimuth angle for geologic studies (e.g., Jeffries, 1969; Dellwig et al., 1968, MacDonald et al., 1969).

It is often emphasized that for best results there is a need for multiple and orthogonal azimuth angles when searching the data for geologic faults (e.g., Harwood, 1967). For urban areas we shall demonstrate that orthogonal look-directions (or azimuth angles) do not necessarily produce the optimum radar data.

Eppes and Rouse (1974) have quantitatively studied the problem of the effect of azimuth angle variations on the detectability of surface features. They dealt exclusively with linear features which have some topographic expression. The results of their labo-
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Laboratory study indicate that proper spatial filtering in the Fourier plane of the radar image having a single azimuth angle could provide a detectability of the linears equivalent to that obtained by several sets of radar data taken at multiple azimuth angles. Obviously, this approach can effect a considerable savings in data collection and, although increasing processing costs, the overall result will be a lower expenditure for essentially the same information.

To date there has been little interest in the radar interpretation and application community to continue the approach initiated by Eppes and Rouse (1974). However, the need for a revitalization may be imperative due to the type of data which are to become available in the near future from Seasat-A and Shuttle Imaging Radar-A (SIR-A).

THE LOS ANGELES AREA

A set of SAR data of the Los Angeles area was obtained on 25 May 1977 as part of a joint European/United States aircraft Space Shuttle simulation program. The radar system used was the NASA L-band (1.215 GHz) radar operated by the Jet Propulsion Laboratory and mounted on the NASA CV-990 aircraft. Only HH polarization and 20 m resolution radar imagery are discussed. Figure 1 shows the flight tracks of the aircraft when obtaining the radar data over Los Angeles. The cover figure is a mosaic composed of the ten north-south data runs shown on Figure 1. Density data derived from the mosaic, which is composed of densitometrically and geometrically corrected SAR data (Bryan et al., 1977), were used for this present study. Within this mosaic a series of target areas of residential and commercial land use was used to test the effect of radar azimuth angles on the resulting image tone. The following discussion describes the results of this study.

Large sections of the Los Angeles urban area (cover) have decidedly different grey tones. By concentrating on those areas which are of the mid-grey tones, thus discounting the very dark (gravel pits, airports, flood control areas) and the very bright (industrial areas), we note that the tonal changes are generally well-defined, have geometric patterns with linear boundaries, and are many resolution cells in size.

The cause of the formation of the boundaries and the included grey areas is, then, an interesting aspect of the imagery to be considered. Changes in the land cover across the boundaries seen on the SAR imagery are not apparent. All of the study sites which will be discussed were composed of residential and/or small commercial (2-3 story) structures. The only contrast detected through auxiliary information (e.g., ground truth, maps, aerial photography), which correlates with the linear boundaries of the grey areas as seen on the SAR data, is that of the street patterns. Thus, although the street patterns within the Los Angeles urbanized area are generally rectilinear, not all are oriented in the same direction with respect to true north. This is a result of several historical factors, including (1) the development of individual towns around isolated centers and their growth into a complex of suburbs, (2) the street pattern following the original rancho boundaries, and, in several cases, (3) the fitting of streets to the topography. Consequently, by using radar data obtained at a constant azimuth angle and noting the changes in the grey tones, we can identify those areas in which the azimuth angle of the radar is critical for the change in grey tone.

Large-scale vegetation has been previously noted to be an important factor in the radar backscatter of urban areas (Bryan, 1974, 1975). That effect is primarily to mask the various point targets. Consequently, the result is the smoothing of some ground detail. Although this also occurs in the Los Angeles data under discussion (because large areas and patterns are being studied),

![Fig. 1. Flight tracks flown by NASA CV-990 while collecting Los Angeles data. 25 May 1977.](image-url)
the effect of vegetation is not pronounced. Also, because the radar system used has a 25 m resolution, the detailed effect of vegetation has been reduced.

Description of the Sites
Six sites, labelled A to F and listed in Table 1, were selected for this study. Site A: (Figure 2, Burbank). In this scene the majority of the streets are oriented in three directions, at 044°, 068°, 008° (and orthogonally) although there are some variations such as Clybourn Avenue (340° and 350°). The dominant land use is single family residential with major strip commercial areas along Burbank Boulevard, Magnolia Boulevard, and Olive Avenue. The strongest returns are from areas where the streets are oriented true north-south or east-west. The radar orientation is 090° (Table 1). The extremely bright point return in the south central portion ("D" on Figure 2) is from the buildings of the Disney Studio which are oriented north-south within an area where all other buildings and streets are skewed to the north-south grid. Freeways and major streets appear as dark (no return) areas.

Site B. This area is quite similar to Site A with respect to street pattern and radar return. In the areas of darker tones the two major street orientations are 021° and 042° (and their orthogonal directions). The light toned areas have streets oriented to the cardinal points.

Site C: (Figure 3, San Marino, San Gabriel, Temple City). For the first two examples, the radar azimuth was 090°; for Site C this angle has been rotated to 269°. Again, those areas with streets oriented to the cardinal points of the compass are high return areas, and areas within which the streets are

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Fig. 2. Study Site A - Burbank, California. Radar azimuth is 090° true. (a) L(HH) SAR image; (b) Sketch map of street patterns.
B: Burbank Studios
D: Disney Studios
LGCH: Lakeside Golf Course of Hollywood
NHP: North Hollywood Park
SJMC: Saint Joseph Medical Center

Fig. 3. Study Site C - Alhambra, San Gabriel, San Marino, and Temple City, California. Radar azimuth is 269° true. (a) L(HH) SAR image; (b) Sketch map of street patterns.
AMGC: Alhambra Municipal Golf Course
SGCC: San Gabriel Country Club
not parallel or orthogonal to the radar azimuth angle have significantly lower return. The dark grey area to the east is a portion of Temple City in which the streets are oriented at 075°, 079°, and orthogonally. The boundaries of this area are Duarte Avenue, Baldwin Avenue, Encinita Avenue, and Longden Avenue. The southern boundary of this grey zone is quite diffuse because there are very few streets in this area, which is composed primarily of large storage yards and light industry (in the vicinity of the Southern Pacific Railroad and Eaton Wash).

In the west portion of the study site is a similar grey area composed primarily of portions of the Alhambra and San Marino political divisions. Boundaries here are Garfield and Atlantic Avenues (to the west) and the Southern Pacific Railroad (to the south). The eastern boundary follows a series of interconnecting street patterns.

Two golf courses, the Alhambra Municipal and the San Gabriel Country Club, are easily identified as areas of very low returns within a zone of cardinally oriented streets. Also of major interest are the bright linear features which are portions of Eaton Wash. This is a normally dry wash (25 feet wide and 10 feet deep) with vertical concrete walls and bordered by a chain link fence. This feature is easily followed where it is parallel to the flight track (and therefore normal to the radar azimuth direction). As in the case of the railroads, it can often be traced as a dark linear feature due to the relatively broad right-of-way through the majority of the San Gabriel portion of the image.

Site D: (Figure 4, Los Angeles). This scene, from the central portion of Los Angeles and centered on the University of Southern California (USC) and Exposition Park (EP), provides an opportunity to note the fine degree to which the street patterns can be identified using the L-band, 20 m resolution radar. USC and Exposition Park are both large dark grey areas on the image with individual buildings providing some point returns within these dark zones. East of Exposition Park and north of Santa Barbara Street is an area of major interest. For these data the aircraft track was 188°, the radar azimuth was 278°, and the radar was oriented 8° off the normal with respect to the north-south oriented street grid and approximately 12° off normal with respect to the majority of the other streets. The small area bounded by Figueroa Street and the Harbor Freeway, an area of north-south streets, is only two city blocks wide but is of sufficient width to appear as a bright pattern on the SAR imagery.

East of this, six areas of alternating street patterns are clearly seen on both the radar imagery and the street pattern maps.

The area between Figueroa Street and Main Street consists primarily of low (2-3 story) commercial structures. East of Main Street residential units consisting of single family buildings and small multi-family units predominate. Also, for the two blocks south of the Santa Monica Freeway and for all of the area between the Harbor Freeway and Main Street, the land cover is composed primarily of similar commercial buildings and associated parking lots. This again emphasizes the lack of effect that the differentiation in cultural land cover has on the overall tone of the SAR imagery.

This angular effect is also strikingly portrayed in the western portion of this study area. Here, with the exception of the neighborhood of the Southern Pacific, the land cover is primarily residential units. The bright return at the southwestern corner of Leimert and Santa Barbara is the Andubon Junior High School.

Site E: (Figure 5, Inglewood, South Los Angeles). Both land-use categories are included within this image. The eastern portion (high returns) is composed of streets which are within 8° of being parallel or orthogonal to the radar azimuth. In the central portion of the image, two small linear units centered on Matilz Avenue and Byrd Avenue.
FIG. 5. Study Site E - Inglewood, South Los Angeles, California. Radar azimuth is 278° true. 
(a) L(HH) SAR image; (b) Sketch map of street patterns. 
CP: Centinela Park 
HP: Hollywood Park 
IPC: Inglewood Park Cemetery 

The large Inglewood Park Cemetery and Hollywood Park race track are areas of no streets and, consequently, very low returns. Also, the small area centered on Spruce Avenue and that area to the north of Centinela Park both appear similar on the radar image tone. However, the land use is quite different, with the former being small commercial structures and parking lots and the latter composed primarily of single family residential units. Thus, this portion of the image emphasizes the dominance of the street pattern and the decreased dependence of the tone of the L-band radar image on the land cover.

Site F: (Figure 6, Pico Rivera, Whittier). The right angle grid system of the City of Whittier, oriented to the cardinal points of the compass, is clearly outlined by several streets (Norwalk Blvd., Whittier Blvd., Washington Blvd., College Ave.) and, to the north, the Puente Hills. Several small areas where canyons and the park-like atmosphere of Whittier College ("WC" on Figure 8) disrupt the regular grid pattern and are defined on the radar image as areas of very low return surrounded by the higher return of the parallel and orthogonal streets.

In the central portion of the image and west of the intersection of Hadley St. and Whittier Blvd., the high return is not the result of the street pattern. Here a strip commercial development in the midst of an area of rectangular street patterns oriented approximately 40° from the radar azimuth angle causes the higher returns.

To the west of the San Gabriel River, isolated bright returns in Pico Rivera are again the result of small areas of streets parallel to the radar azimuth angle. The extremely bright return northwest of the corner of Passons Blvd. and Washington Blvd. is the El Rancho High School complex in Pico Rivera. These are oriented in a north-south direction and are, therefore, parallel to the aircraft flight track.

In Whittier immediately west of Whittier Blvd. and north of Washington Blvd. a bright north-south linear is a small access road to the light industries. To the west are large relatively open areas which are dark on the radar imagery.

The bright returns between Washington Blvd. and Rivera Rd. have a few north-south oriented streets with many commercial industrial buildings oriented parallel to the streets. However, between Rivera Rd. and Slauson Ave. a few alleyways exist for access.
to buildings which are oriented approximately 20° off the north-south lines.

Finally, on this image, it is noted that in the central part of Whittier (in the vicinity of Milton Ave. and Hadley St.) the effect of the street pattern is seen in the strong return in this area of small shops and commercial services. Also, to the north and west (toward the intersection of Beverly Blvd. and Milton Ave., and beyond) the land use changes but the street pattern continues to dominate the radar return.

**Discussion**

The lack of correlation of the actual land use (low commercial and residential units) and the radar image tone is apparent. These urban data and previous works have emphasized that the angles at which the radar energy strikes a reflecting surface is a major control of the backscatter (brightness) of the radar image. We are not concerned here with the other properties of the surfaces such as surface roughness, dielectric constant, construction materials, vegetation cover, etc., all of which have a definite effect on the radar backscatter. What it interesting is the apparent consistency of the relationship between the radar azimuth angle, the street pattern, and the change in overall grey tone.

In order to test this effect and to define the angle, a graph plotting the grey level against theta (defined as the angle between the radar azimuth and street orientation, as referenced to true north) (Figure 7) is presented. In this figure it is noted that, for areas where theta is less than 10°, the radar image is bright (116 to 193; average = 152). In areas where theta is greater than 10° the image brightness is considerably lower (93 to 128; average = 115). The critical value for theta at which this brightness changes is between approximately 10° and 15°. This critical value of theta is also independent of the land use (with respect to the two broad categories previously defined).

The imaging radar used is designed to simulate Space Shuttle and Seasat-A SAR and provide pre-launch engineering and data interpretation experience and guidance. The Seasat-A incidence angle was 20° (off nadir) whereas for the airborne radar the incidence angle is 0°-45°. We have, then, the possibility that the transfer of interpretation experience from the aircraft to the spacecraft data may be confused by this change in the depression angle. However, because no effect of range is seen with respect to theta on the aircraft data, it is believed that Seasat-A data will show a similar lack of range effect. Preliminary inspection of Seasat-A SAR data show this to be indeed the fact.

There is the possibility that this azimuth angle effect described may be unique to the L-band radar and at this resolution, although we are not able at this time to adequately test this hypothesis. It is recalled that, in earlier papers discussing L-band radar (λ ~ 21 cm, resolution of 30 ft) (e.g., Bryan, 1975), it was noted that, for commercial, industrial and residential areas, land use could be interpreted quite accurately even by inexperienced interpreters. In those data no instances were observed which related the effect of street orientation and radar azimuth as described in the present paper. To further test this hypothesis a set of data, collected by systems operating at the same wavelength but at different resolutions for the same study site, needs to be available. Such data are not presently available.

Imagery at X- and L-band, and HH and HV polarizations, are available, however, for Sun City, Arizona, and permit comparisons of a rather unique urban morphology. In Figure 8, an X-band image (Goodyear, AN/UPD-4) of Sun City, Arizona is presented. Interestingly, we note in the circular patterns of the streets two sets of high returns. These high returns are located at or near tangents to the street pattern which are nearly normal or parallel to the radar...
relationship of street direction versus azimuth angle.

**AN EXPLANATION**

Are street patterns being detected and, if so, why, on the original imagery of Los Angeles, are streets per se often not visible? This would seem to indicate that something other than street patterns is imaged, and that the effect under discussion is evidently caused by features highly correlated with the street pattern. These features may be related to the orientation of the buildings and their walls, which are normally related to the street patterns. In many areas of western society, and in relatively modern towns, a common practice is to construct rectangular buildings parallel to the streets. If the street is curved, the practice is to place the buildings with one side parallel to the tangent of the street curve. Hence, the situations depicted in Figures 10 and 11 arise.

From the earlier discussion we would expect that a radar image obtained with the antenna located at position 1 or 2 (Figure 10) would give a very bright return, and low returns would be obtained with an antenna at position 3 or 4. This would be true if either the orientation of streets or the building walls is the basis for the arguments. If a set of ideally circular streets is used as a model (Figure 11) a radar image from a position of either 1 or 2 should have bright returns. But,

as we note in the Sun City data, such is not the case. In Figures 8 and 9 the antenna azimuths on the strong returns are oriented toward the center of the circular pattern and independent of the straight streets. Those portions of the streets (curbs) which might be available for the bright reflections are of insufficient physical size to yield the bright returns. Therefore, the only remaining items aligned with the observed bright returns would be the walls of the buildings, which are arranged with respect to the streets as indicated in Figure 11. This conclusion is further supported by the data shown in Figure 2. In this figure the Disney Studios, consisting of several large buildings oriented in a north-south direction (normal to the antenna orientation), cause very bright returns. Hence, it is the walls of buildings which cause the bright returns.

For the Los Angeles residential areas, considering that the radar resolution is 20 m, if the street patterns caused the bright returns, it would be expected that the high returns would be concentrated along the actual streets. However, the high returns are rather consistently distributed across large areas. Also, the streets which are smooth and normally imaged as dark (specular returns) would not themselves cause the high returns. Thus, the building walls, forming dihedral reflectors, cause the high backscatter. The depression angle of the antenna (or the incidence angle to the ground surface) has little impact on this particular type of return, and the azimuth angle is the controlling factor. The exact explanation of the critical azimuth angle (theta) of 10° - 15° has not yet been identified; it is presently believed, however, that this is an effect of the radar antenna beamwidth.

Applications

It has often been argued, and rightfully so, that a set of multiple passes using an imaging radar will enhance the accuracy of the interpretation of the radar data obtained. MacDonald et al. (1969) suggest that as many as eight should be made to provide the optimum data set. However, this many passes may be redundant. If some prior knowledge about the orientation of the features to be studied is available, then a set of flight tracks which will be oriented to take advantage of this a priori knowledge can be designated. Assuming that a major interest is to define these linear features rather than to identify the nature of each side of the feature (e.g., two sides of a mountain range) and that radar shadow is not pronounced, imagery from opposite azimuth directions is redundant. Image obtained with the antenna azimuth normal to the linear trend and at an angle of between 15° - 75° from that normal should be sufficient. Thus, knowledge of the flight track is quite important for radar image interpreters. Although there are the possibilities of obtaining Seasat-A data from two different azimuth angles (generally in the north-east and north-west look-directions with an ascending and descending orbit for mid-latitude locations), these angles may not be optimal for change detection of the land-use patterns. In the instant case of Los Angeles, the same areas may be continually imaged as bright or dark, and the effect of azimuth angle may mask some changes in land use. Thus, computer classification of land use may be difficult. This
is, indeed, a problem which is similar to that encountered by users of Landsat data in which, although the timing is consistent, there is a seasonal change of sun angles for each succeeding observation of a given scene. Possibly, for the study of radar imagery, an approach as initiated by Eppes and Rouse (1974) would be a logical, initial point to decrease the dependence of the radar return on azimuth angle. When accurate information concerning the linearity and orientation of the features on the Earth’s surface is available, it should be a relatively simple problem to use filters to subdue or remove this effect. If we are to attempt this approach in the interpretation of satellite radar data, we may encounter limited application for some older or non-western towns. As pointed out by Carter et al. (1977), “There is also (in the United States) a very marked grid system of transportation networks. Such geometrical simplicity is not usual in the United Kingdom.” Nor is it true in all of the U.S. (e.g., New England). Indeed, both of the test cases presented here represent quite young towns.

**CONCLUSION**

This study of 25 cm (L, HH), 20 m resolution radar data has indicated that the difference between the azimuth angle of the radar and the orientation of the streets (or other linear features) is of critical importance. For the Los Angeles area, the angle at which the change in the backscatter is most pronounced is in the neighborhood of 10° to 15°. For this study area radar range (depression angle or incidence angle) is apparently of minor importance in controlling the backscatter from flat urban areas having numerous vertical components in the form of walls. It is determined that an awareness of the lineairties and the orientation of the cultural features will be critical for an accurate interpretation of radar data from either aircraft or spacecraft. Thus processing techniques need to be developed to remove this effect prior to interpretation of an urban area for land-use or change detection investigations. With respect to the satellite data, this need may be more critical than for aircraft data because in the latter case it is possible to change the vehicle flight track to compensate for the orientation of features which are of particular importance and interest.

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**REFERENCES**


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