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Interpretation of Radarsat-1 SAR Imagery of Riyadh for Mapping Applications

Abdullah Salman Alsalman
Civil Engineering Department., College of Engineering,
King Saud University,
P. O. Box 800, Riyadh 11421, Saudi Arabia

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Abstract. A synthetic aperture radar (SAR) image obtained by the Canadian Radarsat-1 system and covering the City of Riyadh is evaluated for thematic accuracy levels required for planimetric mapping applications. After a brief account on the elements and factors affecting radar image interpretation, and the various parameters involved in these processes, a systematic approach was followed in interpreting the various elements that are likely to be shown on planimetric maps. Simple interpretational instruments were used to measure linear features and areas on the radar image. These were then compared with their map equivalents. The results showed that 80% of major roads can be interpreted with conviction; while only 30% of dry streams (wadi's) were discernible. Built-up areas could be interpreted to 85% accuracy and hills and raised ground to 70%. On the other hand, only 10-20% of vegetational areas were correctly identified. Combining these findings with the geometric testes carried out by the present author and other investigators, it seems that reasonable scale range obtainable from Radarsat-1 SAR image type, as tested in this experiment, will be $^{1}/_{100000}$ to $^{1}/_{500000}$. This is commensurate with the requirements of some basic thematic mapping applications such as forestry, hydrology, geography etc.

1. Introduction

Radarsat-1 was conceived and developed by the Canadian Space Agency (CSA). The system was put into orbit by the National Aeronautics and Space Administration (NASA) in 1995 from Vandenburg Air Base in California to monitor global environmental changes such as deforestation, agricultural cycle changes, desert sand movement, sea-ice monitoring, daily ice charts, planimetric mapping cartography, geology, geographic surveys, etc. The Canadian Space Agency was responsible for the design and integration of all system components, its control and operation in orbit, and for the operation of the data reception and processing stations. These are situated in Prince Albert, Saskatchewan and Gatineau (Quebec). Radarsat carried an advanced C-band synthetic aperture radar (SAR) instrument with a wavelength of 5.6 cm, with a steerable antenna and a multi-mode imaging capability.

2. Main Radarsat System Characteristics

Radarsat has a 798-km near-polar, sun-synchronous down-dusk orbit. This means that the satellite is rarely in eclipse or darkness (Fig. 1). Table 1 shows the general orbital characteristics of Radarsat, while Table 2 presents its main system characteristics.

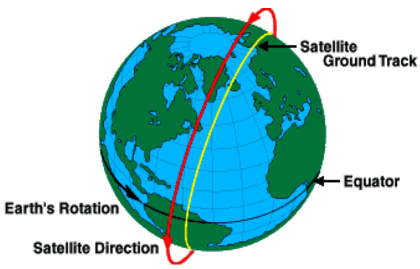

Fig. 1. Radarsat orbit.

Table 1. Radarsat orbit characteristics

Altitude	798 km
Inclination	98.6°
Period	100.7 minutes
Repeat Cycle	24 days
Coverage	7-day and 3-day sub-cycles

Table 2. Radarsat system specifications

Frequency	5.3 GHz
Wavelength	798 km
RF Bandwidth	11.6, 17.3, or 30.0 MHz
Sampling Rate	12.9, 18.5, or 30.0 MHz
Transmit Pulse Length	42.0 μs
Pulse Repetition Frequency	1270 to 1390 Hz
Transmitter Peak Power	5 kw
Transmitter Average Power	300 W
Average Radar Data Rate	73.9 to 100.0 Mb/s
Antenna Size	15.0 × 1.5 m
Mass	2750 km
Solar Array	3.5 kw
Batteries	3× 48 Ah NiCd
Design Lifetime Resolution	5 years 100 m (wide mode W), 50 m (S1 mode), 10 m (F2 mode), 5 m (ultra fine mode F1)

3. Radarsat Products

Products from Radarsat data consist of SAR images and/or signal data stored in magnetic, optical or electronic media. These products are designated by the beam mode used to produce them, the position of the satellite and the level of processing that has been applied to it. Table 3 summarizes Radarsat-1 product types and levels.

A number of investigators reported on the inherent geomatic accuracy of Radarsat-1 imagery and its potential for mapping applications on this basis (e.g., Alsalman, 2009; Ali, 2007). The results obtained in this respect are summarized in Tables 4 and 5.

As can be noted from Tables 4 and 5, the F2 mode of Radarsat-1 data is suitable for mapping at the scale of around $^{1}/_{50000}$ and smaller, while the standard mode S1 image satisfies the requirements of planimetric mapping at $^{1}/_{100000}$ scale. On the other hand, the wide mode (W) data is commensurate with only the requirements of $^{1}/_{400000}$ scale and smaller. These results show only the levels of geometric (or metric) fidelity of the data. The thematic content of these images was not adequately addressed, however.

The aim of this article is, therefore, to investigate the interpretability of Radarsat images for planimetric mapping applications. The results are believed to fortify the geometric tests carried out elsewhere.

Table 3. List of Radarsat products

Processing Level	Product Type Radarsat-1 Mnemonics	Product Type Terminology	Product Level
RAW (signal data)	RAW	RAW signal data	
Georeferenced data	SLC	Single Look Complex	Level 0
	SGF	Path Image	
	SGX	Path Image Plus	
(Satellite path oriented)	SCN	ScanSAR Narrow	Level 1
	SCW	Scan SAR Wide	
Geocoded Data	SSG	Map Image	Level 2
(Map oriented)	SPG	Precision Map Image	

Table 4. Results of Radarsat images using linear conformal transformation (Alsalman, 2009; Ali, 2007)

Radarsat	Easting r.m.s.e Easting	Northing r.m.s.e Northing	Planimetric Accuracy (m)
Riyadh test area using two control points (Alsalman,2009)			
Fine Mode(F2)	± 227	± 131	± 262
Standard Mode(S1)	± 285	± 173	± 333
Kassala test area using two control points (Ali,2007)			
Wide mode(W2)	± 245	± 183	± 306
Standard Mode(S7)	± 219	± 170	± 277

Table 5. Results of the accuracy of the two test areas using polynomials

Type of Transformation / Type of Test Image		Linear Conformal Transformation	First Order Polynomial Transformation		Second Order Polynomial Transformation		Third Order Polynomial Transformation	
		Check points n = 6	Control points n = 9	Check points n = 4	Control points n = 11	Check points n = 3	Control points n = 12	Check points n = 3
Riyadh test area (standard mode S1) (Alsalman, 2009)	σ_X (m) σ_Y (m) σ_P (m)	± 285 ± 173 ± 333	± 102 ± 119 ± 157	± 74 ± 110 ± 132	± 49 ± 19 ± 52	± 132 ± 48 ± 141	± 9 ± 3 ± 10	± 61 ± 64 ± 88
Riyadh test area (fine mode F2) (Alsalman, 2009)	σ_X (m) σ_Y (m) σ_P (m)	± 227 ± 131 ± 262	± 2 ± 205 ± 206	± 37 ± 146 ± 151	± 107 ± 235 ± 258	± 153 ± 164 ± 225	± 24 ± 13 ± 28	± 39 ± 49 ± 62
		n = 6	n = 6	n = 5	n = 7	n = 4	n = 9	n = 3
Kassala test area (standard mode S7) (Ali, 2007)	σ_X (m) σ_Y (m) σ_P (m)	± 219 ± 170 ± 277	± 70 ± 134 ± 151	± 101 ± 274 ± 292	± 56 ± 84 ± 101	± 101 ± 150 ± 181	± 20 ± 42 ± 47	± 84 ± 103 ± 133
Kassala test area (wide mode W2) (Ali, 2007)	σ_X (m) σ_Y (m) σ_P (m)	± 245 ± 183 ± 306	± 62 ± 156 ± 168	± 114 ± 296 ± 317	± 82 ± 196 ± 213	± 66 ± 312 ± 319	± 20 ± 20 ± 28	± 50 ± 88 ± 101

4. Test Area, Design and Procedure of the Test

The image used to test Radarsat-1 image interpretability was made available to the author by King Abdulaziz City for Science and Technology in Riyadh, Saudi Arabia under the kind sponsorship of the Research Center of the College of Engineering at King Saud University in Riyadh. The image covers Riyadh, the capital of Saudi Arabia, and its environs.

5. Riyadh Test Area

Riyadh District Area (Central Region) is located in the center of the Arabian Peninsula at latitudes 24° to 28°N and longitudes 43° to 46°E, and comprises an area of around 100,000 km^2. It has an average elevation of about 600 m above mean sea level. This vantage location has given Riyadh City a strategic dimension where it is considered as the connecting region between the east, west, north and south of Arabia, in addition to the strategic importance of the Arabian Peninsula which is linking the two biggest continents, Africa and Asia (Alsalman, 2008). During the past two to three decades, the city has witnessed a high growth of population estimated to be 8% annually (Elhassan, 1990; Ali, 1993). The present population of the city (2008) is about 5 million, and it is expected to reach 9 million by the year 2015. The test area comprises many urban areas, rural districts, various land types and a few agricultural lands. This is believed to be advantageous for the purpose of the present experiment since it combines a range of various features on the imagery to be tested. Figure 2 shows the geographical location of Riyadh test area; while Fig. 3 shows the test image used in this experiment.

6. Riyadh Radarsat Image Interpretation

No image measurements can take place without some degree of interpretation. Therefore, in this experiment, an attempt has been made to establish what can be discerned on Radarsat imagery using the details required for standard small-scale topographic mapping as the yardstick for the study (see, for example, Elhassan and Ali, 1995; Morain, 1976; Ali, 1986; Sabins, 1987).

It is now well-known that since a SAR image and an aerial photo are produced by entirely different sensors in terms of their wavelengths, methods of operation, geometry, etc., the appearance of the same piece of ground will be entirely different on the two images. What appears on the one image may not appear on the other. Since the photographic interpretation process itself and the results likely to be produced from the interpretation of photographs at a given scale are very well known and established, while that of SAR imagery is unfamiliar, the main factors influencing SAR image interpretation will first be outlined. This is followed by an account of the actual experiment carried out on the image available to the author to establish what can (and cannot) be detected and interpreted on the Radarsat image of Riyadh in terms of topographic detail.

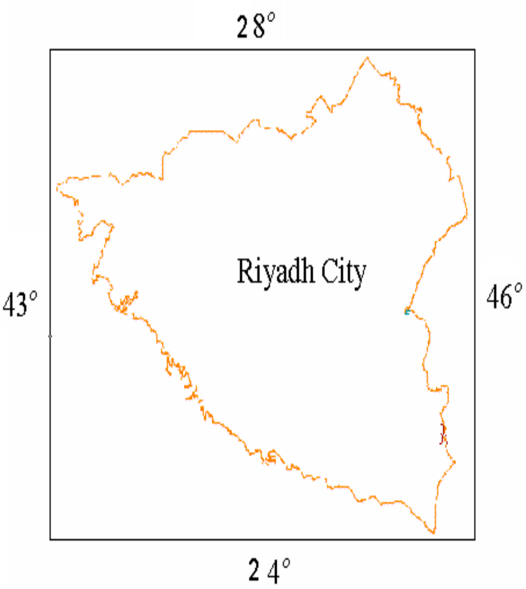

Fig. 2. Geographic location of Riyadh test area.

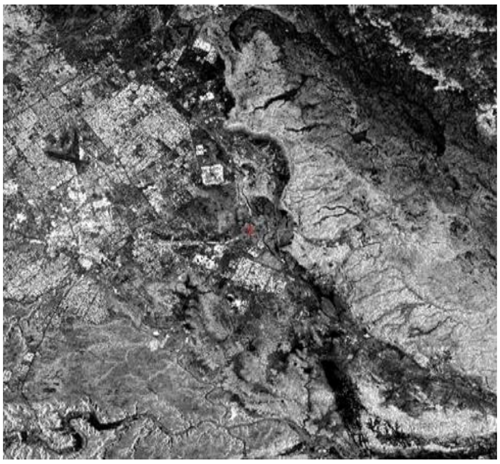

Fig. 3. Riyadh Radarsat image fine mode F2.

7. Factors Affecting Radar Image Interpretation

Apart from the interpreter's own abilities and aptitude, there are two main groups of factors which influence the interpretability of features shown on the radar image. These arise from:

(i) the radar system geometry, and
(ii) the backscattering characteristics of the terrain and of the objects present on it.

As regards radar system geometry, the most important radar system geomery parameters are (a) the system resolution, (b) the direction in which the imaging is taking place (linear features, for example line of trees, are clearly visible when oriented parallel to the ground track), (c) the general characteristics of the terrain surface itself with respect to the incident energy of the SAR pulse, e.g. terrain slope, and (d) the incident angle between the direction at which the radar pulse strikes an object and the normal to the surface (which defines the conditions for the extent of the backscatter and reflectivity of the incident pulse) (Sherwin, Runia and Rawclliffe, 1962; Brown and Porcello, 1969; Cutrona and Hall, 1962; Kovaly, 1976; Skolnik, 1970; Raney, 1977; Wells, 1974; Clynch, 1979).

As far as the backscattering characteristics of the terrain and objects are concerned, the variation in the degree of reflection of the incident radar pulse towards the antenna considerably influences the appearance of a certain object on a radar image and hence its detectability and interpretability. The actual backscatter which will be present is a function of both the system parameters and the terrain and object characteristics and their interaction with one another. The most important parameter of the radar backscatter is the degree of surface roughness. In this respect, a surface imaged by a SAR is considered to be smooth in terms of transmitted wavelength if it is related to the wavelength by the following relationship (referred to as Rayleigh Criteria).

$$hr < \frac{\lambda}{8 \sin\mu}$$

where:

hr = surface roughness;
λ = radar wavelength; and
μ = angle of microwave incidence.

Thus, the general rule is that the rougher the surface compared with the wavelength, the more energy will be reflected to the antenna (see Elhassan and Ali, 1995; Rye and Wright, 2005; Ali, 1987; Deane, 1973).

Normally, several different categories of surface roughness are distinguished. Specular reflection takes place when the surface is smooth. Virtually all the energy is reflected away from the antenna and the surface appears totally black on the image. Such surfaces give very low radar returns, except when they present a surface normal to the incident radar energy (Fig. 4), when a very strong return signal is produced.

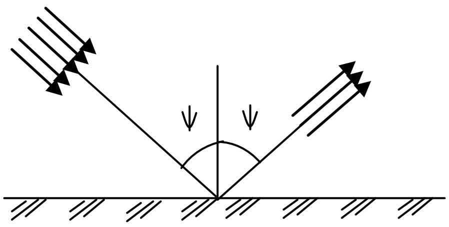

Fig. 4. Reflection of radar energy at smooth surfaces (most incident energy is reflected away from the antenna).

If, however, surface irregularities are comparable with the wavelength, the energy will be reflected in a quite different manner, usually referred to as diffuse or scattered reflection (Fig. 5).

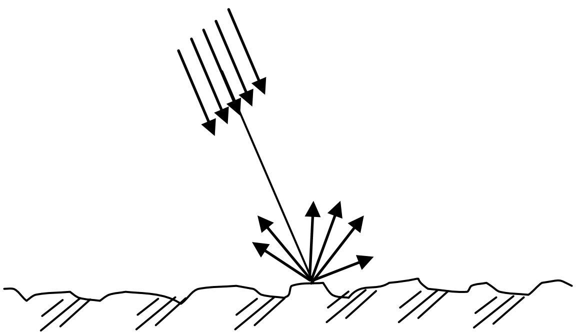

Fig. 5. Smooth and different reflections.

Surfaces which produce scattered reflection are woodlands, forests, crops, parks, etc. The reflected energy will produce an image of immediate brightness, its actual appearance being dependent on the proportion of the incident energy back-scattered to the antenna. This, in turn, will depend on the characteristics of the object itself and the degree of surface roughness which it exhibits.

On the other hand, if a surface is normal to the incident radar rays, virtually all energy will be reflected back to the antenna and the object will subsequently feature very bright on the image (Fig. 6). Rocks and raised ground are examples of this phenomenon.

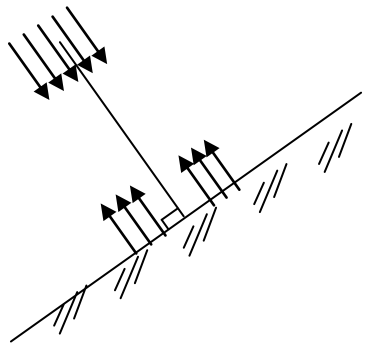

Fig. 6. Surfaces making right angle with incident radar rays reflect strongly towards the antenna.

8. Elements of Radar Image Interpretation

In attempting topographic mapping of ground features from radar imagery, one must understand that the radar image of a specific area will inevitably be very much different in appearance from the corresponding aerial photographic image of the same area taken by a conventional photographic film or digital camera. Thus, the normal experiences and procedures derived from photographic interpretation will often have limited application to the interpretation of radar images (see, for example, Barnett, Smith and Welford, 1978; Bennet and Cumming, 1979; Ulaby and Shanmugam, 1984). It may be useful to review the usual set of factors: size, shape, shadow, tone, pattern, site and orientation listed as important in aerial photographic interpretation and attempt to assess their relevance to the particular case of topographic mapping from radar imagery of Riyadh as carried out in the present experiment.

(i) **Size:** In the context of radar, the size of an object should normally be greater than the nominal resolution of the image for it to be detected and identified. It should also be noted that the measurements of the sizes of objects on the radar image may only be fruitful if large inherent geometric errors are removed at a preliminary stage in processing.

(ii) **Shape:** The direction from which the radar "looks" at an object can greatly affect the shape of that object recorded on the radar image. Thus, the shape may well be falsified or misleading in that certain features of the object may be visible or prominent on the image, while others will not be present; solely due to the orientation of the object with respect to the imaging direction of the radar system itself. As a result, it is not always easy to visualize how a particular ground object will be represented on the SAR image and to make allowances for the direction in shape which will result from the inconsistencies in signals backscattered to the receiver arising from this effect.

(iii) **Tone:** This relates to the varying amounts of energy reflected to the antenna from the objects. Objects will often be distinguished by the differing tones or intensities appearing on the SAR image. However, the amount of back-scattered energy depends, among other factors, on the properties of a specific object, e.g. its composition, its orientation with respect to the antenna at time of imaging, etc. These are factors which are not always apparent to the interpreter, who may find it difficult to take account of their effect in particular set of circumstances.

(iv) **Pattern:** This is the spatial arrangement of the components of an image, e.g. man-made features may often exhibit a systematic pattern. However, in the context of radar, care has to be taken since the systematic pattern visible on a specific radar image may result wholly or partly from the relationship of certain features to the imaging direction of the radar system. In view of this limitation, the detection or presence of patterns may not be important in the context or radar image interpretation for topographic mapping as it is in aerial photography.

(v) **Shadow:** The presence of this characteristic may help interpretation, for it may show the shape of an object. However, in the context of radar imagery, it should be remembered that shadows occurring on radar images are in fact total voids in the image, whereas on a photographic image detail may still be discerned in the shadow areas. These image voids are of course a major difficulty in interpreting or mapping a radar image for which there is no cure whatsoever.

(vi) **Site (or location):** The location of an object with respect to the surrounding terrain features is of course a most helpful item to employ in the detection and interpretation of a certain feature on a radar image. This is very important for many ground features where the presence of features such as small rivers will only be detected through the knowledge of trees on their banks.

9. Interpretation of Radarsat SAR Imagery of Riyadh

Having introduced the basic elements of SAR image interpretation and the various parameters that are likely to be involved in the process, it is now possible to see how the interaction of these factors affected the interpretation process of features known to exist on the imagery and are depicted on the topographic map of the area. Since the geometric fidelity results reported by Alsalman (2009) and Ali (2007) (as shown in Tables 4 and 5 above) showed that Radarsat SAR imagery satisfies planimetric mapping requirements at $^{1}/_{400000}$ to $^{1}/_{500000}$ depending on image acquision mode (fine, standard or wide), it is feasible now to evaluate and assess the content of the image as regards ease of interpretation of features normally depicted on topographic maps at such scale range. The interpretation test has been carried out by first making a list of these features. The features were grouped into five categories. These are:

(i) Lines of communication.
(ii) Settlements and cultural features.
(iii) Hydrology.
(iv) Vegetation.
(v) Physical and relief features.

Using a magnifying glass and a lens stereoscope, the detection and identification of these features was attempted. Features which were not detected using the stereoscope despite expectation were either visited on site or people with good reference level of the area were approached and asked about these features. Interpreted features were measured using a simple map measurer on a 3X print enlargement of the original SAR image. The measured lines (or areas) were then converted to ground terms by using the scale factor. The results of the interpretation process were as follows.

9.1. Lines of communication

In the City of Riyadh, these include motor roads, A-class roads, B-class roads, secondary roads and railroads. Roads whose orientation are parallel or roughly parallel to the ground track of the satellite can be detected. They show up as light-toned straight lines. However, in most cases, once a certain road changes its direction, it ceases to be discernible. This is a conclusion reached by others (Ali, 2007; Elhassan and Ali, 1995; Ali, 1987; Ali, 1982; Haralick, 1970; Olliver and Quegan, 1998). The many narrow roads between individual residents were difficult to detect, interpret and discern on the imagery. The only railway line joining Riyadh to the Eastern Region cannot be seen at all. Surprisingly, many of the unsurfaced roads and tracks on the fringes of the city can easily be seen, especially if they lie in a direction parallel to the satellite ground track.

9.2. Settlements and cultural features

These can be divided into four groups, i.e. built-up areas, bridges, airports and power lines.

(i) **Built-up areas:** These appear as large very bright patches on the imagery which can easily be recognized and interpreted. The boundaries between the various districts (Hai's) could easily be defined. Many isolated buildings could be seen and interpreted. However, it is difficult to tell to which kind a certain detected building belongs, i.e. residential or industrial, etc.

(ii) **Bridges:** Many fly-over bridges exit in Riyadh. Some of them can be detected easily, e.g. those serving as junction points of highways on the fringes of the city. Those inside the city cannot be seen at all.

(iii) **Airports:** The runways of the Riyadh Airbase in Sulaymania can easily be seen as very dark lineations surrounded by bright tones caused by buildings. The part of King Khalid International Airport imaged by the satellite is clearly visible. Even the catering warehouses beside the airport can be detected.

(iv) **Power lines:** There is a complete absence of all powerlines in this Riyadh image. Even the large power transmission pylons in Al-Suwaidi cannot be detected with conviction.

The very large telecommunication aerials north east of Al-Naseem show up very clearly and could be detected without the help of the map. Other telecommunication towers inside Riyadh are not easily discernable.

9.3. Hydrology

In the Riyadh Area, these include dry streams (wadis) and sewage treatment plants. Wadi Haneefa, which runs east-west, or south/east-north/west, can be detected for a short portion of its length. Many parts of its length cannot be detected without the help of the map. Wadi Laban (which is a tributary of Wadi Haneefa) can be detected only with the help of the topographic map of the area. In this respect, it is difficult to think that such information will be useful for topographic mapping.

9.4. Vegetational features

These include woodlands, orchards and recreational parks.

(i) **Woodlands:** Very few woodlands exist in the Riyadh Area, most of which are found along the banks of Wadi Haneefa and Wadi Laban, and are composed of some acacia and date trees (palms). None is detectable on the Radarsat SAR image of the test area, even with the help of the map or the help of the 1998 SPOT multispectral image (xs_1, xs_2, xs_3) of the test area.

(ii) **Orchards:** Some orchards exist on the banks of the two Wadis. None of them was detectable.

(iii) **Ornamental grounds:** Many recreational parks exist in the City of Riyadh. Those surrounded by buildings are relatively easier to detect and interpret. They show up as dark tones embedded into the strong reflections of the buildings. However, many are either just detectable with the help of the map or undiscernible at all on the image.

9.5. Physical and relief features

Hilly areas, high ground, Wadis, depressions, etc., can be recognized on the image and can give impression about relative terrain relief, but no actual definitive mapping of the type needed for a topographic map can be undertaken.

10. Quantitative Evaluation of Feature Identification

Having outlined the circumstances of feature detection and identification on the test image, a more quantitative evaluation of the SAR image of Riyadh could then be contemplated. For this, linear and areal measurements were made on the five groups of features mentioned above. The 3X enlargement print (scale $^{1}/_{50000}$ after enlargement) was used for this purpose because it conforms to the scale of the topographic maps used to aid the interpretation process. Other collateral information was available in the form of an old aerial photographic mosaic, topographic maps compiled in 1987, a recent 2005 Quickbird satellite imagery of the test area and the reference levels of the author about the area.

Using a simple map measurer, the length of all line features such as roads, water courses, lines of telecommunication, etc., were measured on the image and then compared with their lengths as derived from the topographic maps. This is done by measuring feature dimensions on the image in millimeters and then multiplying the result by the scale factor of the image (1 mm on image corresponds to 150 m on the ground). The latter result is then compared with the dimensions as derived from the map. As far as roads are concerned, emphasis was placed on major roads of the city, e.g. Airport Road, King Fahad Motorway, Khurais Road, King Abdulaziz Street, etc. Areal features, such as settlements, small clumps of vegetation, hills, etc., were measured using a gridded paper. The measured areas were then compared with their map equivalents.

The results of this part of the test showed that, among line features, major roads were much more interpretable than other line features. Thus, about 80% of the total lengths of major roads were correctly identified on the imagery. However, only about 30% of the lengths of Wadi Haneefa and Wadi Laban were correctly identified. On the other hand, about 65% of the length of the King Saud University boundary fence was correctly identified.

Areal features, such as blocks of buildings in Olaya, Khasm Alan, Alnaseem, Industrial City, Al-Dariya, Diplomatic Quarter, Ashifa, etc., could be identified to about 85% accuracy on the Radarsat imagery. Hills and rock features exhibited an interpretational accuracy of about 70%, while only 10-20% of vegetational features were correctly identified on the image.

11. Combining the Geometric and Interpretational Test Result and Conclusions

While Radarsat radar system represents one successful commercially-available SAR data from North America, it seems that it still cannot deliver all information necessary for the compilation of medium-scale planimetric maps. One obvious reason for this is the method with which the data was correlated. Such methods do not seem to be of the excellent level experienced with other remote sensor data such Spot and Landsat data. It has already been shown by earlier investigators (see, for example, Ali, 1987) that the method with which the SAR data was processed does in fact govern the overall geometric accuracy and thematic content of the image. As was noted from the results of the present interpretative test, the two main difficulties experienced were firstly deficiencies in image quality and secondly, detection difficulties associated with the orientation of features relative to the direction of the radar signal. In the first case, the effect of background clutter considerably reduces the interpretability of the imagery. In the second case, the detection of linear features in particular seems to be highly dependent on their orientation relative to the radar signal. The consequence of this is to produce rather inconsistent sets of results where features may or may not appear depending on their orientation relative to the satellite track.

Judging from the degree of detail visible on the test area, the overall percentage of the information which can be extracted from the Radarsat SAR imagery as experienced in this test can be estimated to be in the range of 50-60%. Although the geometric tests carried out by the present another (Alsalman, 2009) revealed that Radarsat SAR imagery is compatible with mapping at a scale range of $^1/_{500000}$ for the fine mode to $^1/_{400000}$ for the wide mode; the interpretational test results reported in this paper showed that only major roads and buildings could be identified to an accuracy better than 75%. Other natural and man-made features are still difficult to identify due mostly to the special imaging characteristics of radar systems, in particular, the certain arbitrariness with which radar sets resolve ground features. So, one many say that reasonable scale ranges obtainable from Radarsat-1 SAR image type will be $^1/_{100000}$ to $^1/_{500000}$ depending on mode of image acquision.

The results of the present experiment, therefore, appeal to radar system designers to consider the necessity to develop methods of improving the interpretability of such imagery. In fact, some progress in this field has been reported by Rye and Wright (2005) using segmentation techniques. However, it would seem that, until some improvements occur in this area, SAR imagery from space is unlikely to be a significant source of information for planimetric mapping at scales larger than $^1/_{100000}$, but may be of greater use in constructing mosaics for basic thematic mapping purposes as practiced in reconnaissance surveys (Ali, 1982; Leberl, 1972; Toutin, 2003; Haralick, 1970; Toutin and Gray, 2000; Olliver and Quegan, 1998, etc.), rough population estimation studies instead of aerial photos (Wedler and Kessler, 1982; Hsu, 1971), forestry and vegetation mapping (Ali, 1987; Kessler and Jano, 1984; Van Rossel and Godoy, 1974; Sabins, 1987), geology and regional settings (Janza, 1975; Elhassan, 1990), hydrology (Morain, 1976; Ali, 1986), mapping of large water bodies and waste disposal site monitoring (Ali, 1986; Ali, 1997; Leberl, 1989; Harris, 1987; Bryan, 1983; Baranba, Philipson and Ingram, 1991; Lyon, 1987; Vincent, 1994; Well, Graf and Forister, 1994; Warner, 1994), etc., where stringent positional accuracy levels are not of paramount importance. Radarsat-1 system designers must have already took into account suggestions for improvement coming from radar image user worldwide. In this respect, the results reported in this experiment may be looked at as a contribution towards the improvement of future satellite SAR systems, e.g. SARSAT-2 and 3 for the various earth science applications.

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تفسير صور رادارسات لمدينة الرياض لأغراض تطبيقات إنتاج الخرائط

عبدالله بن سلمان السلمان

قسم الهندسة المدنية، كلية الهندسة، جامعة الملك سعود،

ص ب 800، الرياض 11421، المملكة العربية السعودية

(قدم للنشر في 2008/12/27م؛ وقبل للنشر في 2009/3/15م)

الكلمات المفتاحية: رادار، بلانمترية، الدقة.

ملخص البحث. أخضعت صورة رادارية من القمر الاصطناعي سارسات الكندي مأخوذة لمدينة الرياض لسلسة من التجارب التفسيرية لتقييم ملائمة هذا النوع من الصور لأغراض ترسيم الخرائط البلانمترية عن طريق استعمال قياس أطوال المعالم الطولية والمساحية على الصورة وعلى الأرض. أثبتت النتائج أن الطرق الرئيسة يمكن تفسيرها بنسبة 80٪ في حين أن أطوال الأنهار الموسمية والجافة يمكن تفسيرها بنسبة لا تزيد عن 30٪، أما المعالم المساحية فكانت نسبة تفسير الأماكن المشيدة 85٪ والجبال والتلال 70٪ في حين أمكن تفسير مساحات الغطاء النباتي بنسبة لا تزيد عن 20-30٪.

وعند جمع نتائج هذا البحث مع تلك التي تحصل عليها من التجارب الهندسية لصور رادارسات يمكننا القول أن صور رادارسات