Urban Change Detection Using POLSAR Measurements with Same and Opposite Direction Orbits

Hajime Fukuchi, Naoya Fukushima, Yusuke Komatsu and Koichiro Kato
Department of Aerospace Eng., Tokyo Metropolitan University
6-6 Asahigaoka, Hino, Tokyo 191-0065, Japan
fuku@tmu.ac.jp

1. Introduction

It is quite useful to grasp ground spatial aspects and its temporal change. Especially in highly urbanized area such capability has very important role for not only development planning but also disaster recovery planning. Satellite-borne optical remote sensing such as meteorological satellite sensing is well established and is used in the press and on the television. However, if there is a need to observe earth surface in the night-time, in cloudy or rainy condition in which normally surface can not be observed due to clouds, optical remote sensing technologies may have difficulty. It is well known synthetic aperture radar (SAR) has operational advantages over optical sensors because of acquisition capability regardless of weather, day/night, smoke, clouds and dust, then it is expected that satellite-borne SAR can be used change detection in unconditional and repetitive basis. Moreover satellite-borne POLSAR has such features that it can observe periodically basis but cost-effective way, and can observe quite wide area but quickly with enough spatial resolution. However, it is also known that SAR observation data is sensitive to look direction due to its side-looking imaging principle especially in well urbanized area where a lot of non-isotropic oriented structure appears[1,2].

In this paper, we analyse several repeated polarimetric SAR observation data over 2 years obtained two look angles observation, ascending and descending orbits. We discussed two change detection cases, one is to realize with same orbit observation with temporal difference and another is with opposite orbit observation. And we show urban change detection can be done even from data pair obtained opposite look direction orbits using polarimetric capability.

2. Data and Analysis

2.1 Data Used and Analysis

We used ALOS/PALSAR observation data over Tokyo suburban area obtained over 2 years period. Table.1 shows examples of the measurements. In this paper these 5 polarimetric observations, one is Descending and 4 are Ascending ones, are used for urban change detection. In Fig.1, look angle or incidence angle of each orbits are shown with thin arrows and satellite movement direction are shown thick ones. Due to this difference of look angles, original data maps obtained from each observation are slanted each other as shown in Fig.1. Registration of these different look angle maps are discussed later.

In order to evaluate degree of change quantitatively, we adopt the following normalized value.

\[ \frac{a-b}{a+b} \times 100(\%) \]

where, a denotes received power obtained temporally old observation and b denotes that obtained from new observation. Due to polarimetric observation, we can derive such normalized power difference for HH, HV and VV observations.
2.2 Analyzed Results

A. Change detection from same look angle observations

Because ALOS satellite orbit is well controlled and can be used repeat-path interferometry, registration of temporally different two maps is done by non-rotational sub-pixel registration using zero-padding FFT process.

Fig.2 shows normalized power difference map of HH observation using about 1.5 years temporal difference. The following areas show large absolute power difference:

A: A big Shopping-mall with large parking area was built.
B: A big used-car shop with many cars parked orderly was opened.
C: Many new residential houses are densely built orderly over wide area.
D: Big apartment buildings are under development.
E: Area within American military base, then it is not clear what happens.

These power differences in these areas can be explained qualitatively by above events during the two observation times. Moreover received power decrease or increase can be interpreted to some extent by analysing building time process of each event.

Fig.3 shows the same map for HV- and VV-polarization observation. It is noticed in these maps we can observe the same changes. In Fig.4, typical scenery at each area is shown. In Fig.5, we compare temporal difference dependence of change detection. Left map is for about 1.5 years change and right one is for about recent 8 month change. This shows the change in area C is relatively recent event.

B. Change detection from opposite look angle observations

As shown in Fig.6, original maps obtained from ascending and descending observations are slanted with each other due to look angle difference. For registration, we adopt Affine-transform over area of concern[1]. Descending observation data are registered over ascending map and the result is shown in Fig.7. By using similar data processing over registered maps with different look angles, we can get power difference map of HH polarization as shown in Fig.8. In comparison to the results shown in Fig.2, we noticed a lot of pseudo-changes. Of course all these changes are not real change but many power differences are due to look angle difference. This typical effect is observed in area F. In this area, there are many residential houses orderly and ascending look angle and building wall orientation angle have nearly orthogonal relation as shown in Fig.10. It is well known in such configuration, cardinal effect[3] make radar signal return large. This kind of effect may be the main reason of pseudo-changes in Fig.8. In Fig.9, HV- and VV-polarization cases are shown. Similar pseudo-changes such as area F are observed in VV-polarization map. However, in HV-polarization map, it seems there are not many such pseudo-changes.

We assume that only real changes make power difference large simultaneously in HH- and HV-polarization map and we made such a map that shows areas where both HH- and HV-polarization power differences are large. The result is shown in Fig.11. It is noted that at least areas A-E are extracted as probable real change during about 1 year.

3. Conclusion

By using repeated POLSAR observation we can extract areas where large scale building activity happens. It is found that even only observation pair with different look angles, ascending and descending, pseudo-changes are reduced by analysing both HH- and HV-polarization data.

References

Table 1 Observation Dates and Orbits

<table>
<thead>
<tr>
<th>Observation Date</th>
<th>Orbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006/6/18</td>
<td>Ascending</td>
</tr>
<tr>
<td>2006/7/21</td>
<td>Descending</td>
</tr>
<tr>
<td>2007/3/21</td>
<td>Ascending</td>
</tr>
<tr>
<td>2007/5/6</td>
<td>Ascending</td>
</tr>
<tr>
<td>2007/11/6</td>
<td>Ascending</td>
</tr>
</tbody>
</table>

Fig. 1 Incidence Directions of two Orbits and Observation Examples

Fig. 2 Relative Difference between Same Orbits (2006.6 – 2007.11, Ascending HH-pol.)

Fig. 3 Relative Difference between Same Orbits (2006.6 – 2007.11, Ascending HV-pol. And VV-pol.)

Fig. 4 Newly Developed Urban Areas

Fig. 5 Relative Difference between Same Orbits (Ascending HH-pol.)
Fig. 6 Observation of Ascending and Descending Orbits

Fig. 7 Registered PALSAR Observation

Fig. 8 Relative Difference between Opposite Orbits (2006.7 - 2007.5, HH-pol.)

Fig. 9 Relative Difference between Same Orbits (2006.7 - 2007.5, HV-pol. And VV-pol.)

Fig. 10 Aerial Photograph of Area F

Fig. 11 Extracted Change using HH and HV data analysis