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Extraction of Average Structure Orientation in Urban Area from POLSAR Measurement

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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. Table 1 shows examples and their usages of urban parameters. POLSAR has operational advantages over optical sensors because of acquisition capability regardless of weather, day/night, smoke, clouds and dust. Moreover satellite-borne POLSAR has such features that it can observe periodically basis but cost-effective way, and quite wide area but quickly with enough spatial resolution. It is expected that the urban characteristics such as density and average size of artificial structures, orientation angles of them and so on, can be estimated from such POLSAR signals as an averaged values over areas of interest. For example, it is reported that an arguments of mutual correlation coefficient of circular polarized backscattering components are sensitive to an orientation of artificial structures in area of concern[5]. Moreover other 2nd-order analyzed values such as Entropy and Angle alpha (H-α)[1] or components decomposition methods have been proposed[2-4] as detailed interpretation of targets characteristics. Relationship between urban structure density and the 2nd 0rder values are discussed[6]. In this paper, we propose estimation method of average orientation angle of structures such as buildings or houses by combining such 2nd order analyzed values.

2. Data and Analysis

2.1 Data Used

Fig.1 shows concept of H-α decomposition. A value H represents randomness of scattering mechanism and is used in the later analysis. Figs.2 and 3 show data used and they are pictures at the same area, Tachikawa western part of Tokyo, taken by QuickBird(optical) and POLSAR(air-borne Pi-SAR and satellite ALOS-borne PALSAR). We measured structure orientation angle, θ as ground truth data defined in Fig.4 from QuickBird picture and 2nd order analyzed values are derived from POLSAR received signals. These values are obtained in each averaged pixel over 10 by 10 PiSAR pixels as shown in Fig.4. It is noted that in PALSAR case we can not distinguish θ information from the map drawn by received signal component intensities.

2.2 Analyzed Results

We derived several 2nd order POLSAR analyzed values mentioned in section 1 and noticed that the following values have high correlation with θ; argument(ϕ) of correlation coefficient in circular polarizations basis, and cross-polarized component(CS) of Dong's 4-component decomposition[3]. Figs. 5 and 6 show θ - ϕ relations obtained from PALSAR and PiSAR(L-band), respectively. It is observed apparent correlation between the values. Median values in each θ range are shown with red dots in these figures. Fig.7 shows these median of ϕ and θ relations derived from several POLSAR observations. It is noticed that these relations have quite similar feature. Fig.8 shows θ -CS relation obtained from PALSAR. It is observed that CS reaches maximum value at θ of around 45 degrees. Fig.9 shows median of CS and θ relations derived

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from several POLSAR observations and shows quite similar behaviours. This relation may be interpreted by rotated dihedral-like behaviour by ground and wall of structure combination. Fig.10 shows θ - median of H relation and shows no significant relation between them. Although H has not high correlation with θ, H can have something to do with degree of structural order shown in Table 1 and it is expected that the H can be used for classification of ϕ into cases of simple scattering and complex scattering. Figs.11 and 12 show again θ - ϕ relations with high H case(top 5 highest) and low H case(top 5 lowest), respectively. It is clearly observed that the in lower H case θ - ϕ relation has much higher correlation feature than higher H case. This means that by combining the 2nd order POLSAR analyzed values, we can expect to estimate the parameters of urban areas more precisely.

3. Conclusion

We propose a combined analysis of H-α, mutual correlation and component decomposition methods to estimate characteristics in highly urbanized area using POLSAR signals. We have shown that average orientation angles of rows of buildings relative to incident angle of POLSAR θ can be estimated from ϕ precisely. It is quite interesting that by this approach we can estimate area averaged urban parameters even if we can not distinguish them from received signal component intensity map due to lack of space resolution.

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Table 1 Examples of parameters in urban area

	How useful? (Application Examples)	
	[Spatial Aspects]	[Temporal Change]
Degree of Structural Order	・Classification of Land Usage (Artificial or Natural, % of Road, Houses, Farm, Garden, ・・・)	・Urbanization history and Development Planning ・Disaster Recovery Strategy
Average Size of Structures	・Classification of Area Usage (Factory, House・・)	・ Urbanization history and Development Planning
Average Orientation Angle	・Access Simulation ・Living Environment (Duration of Sun-shine, ・・)	・Urbanization or road Development history and Planning ・Disaster Recovery Strategy
Density of Structures	・Access Simulation ・Living Environment ・Development Planning	・Urbanization history and planning ・Disaster Recovery Strategy

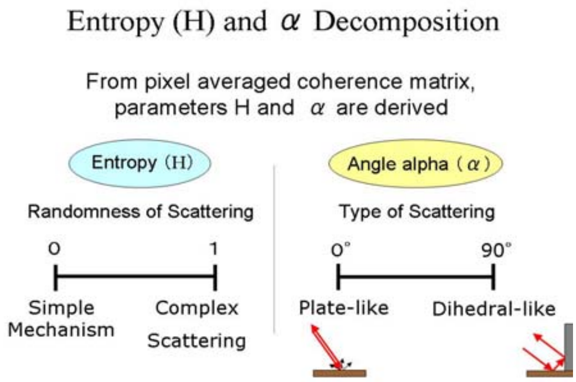


Fig.1 Entropy (H) and α decomposition concepts

Fig.2 Data of QuickBird observation (Optical)

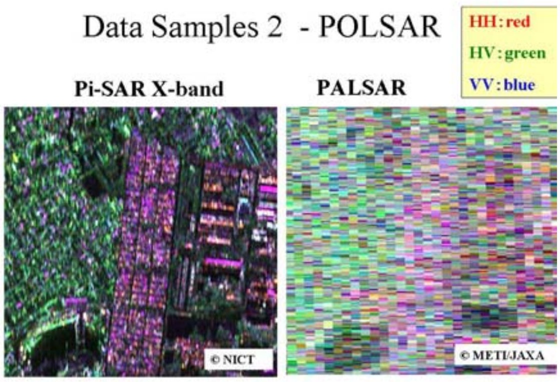


Fig.3 Data of POLSAR observation

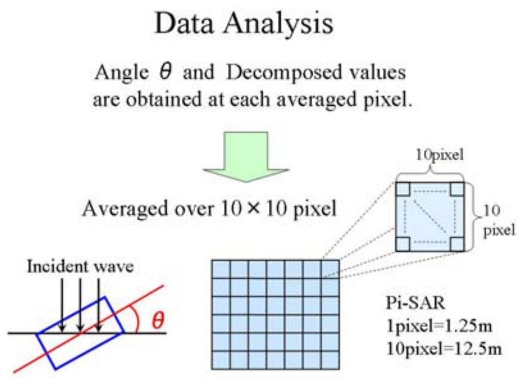


Fig.4 Data analysis procedure (pixel averaging)

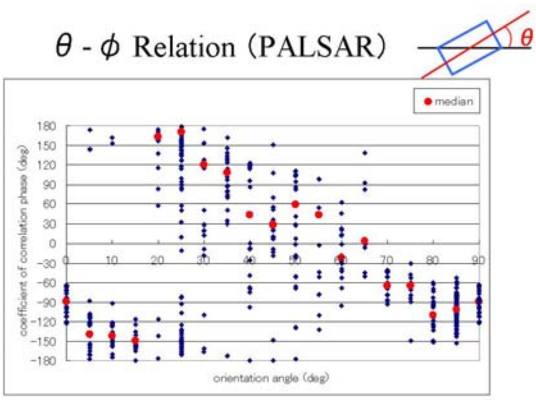


Fig.5 θ - ϕ relation in PALSAR case

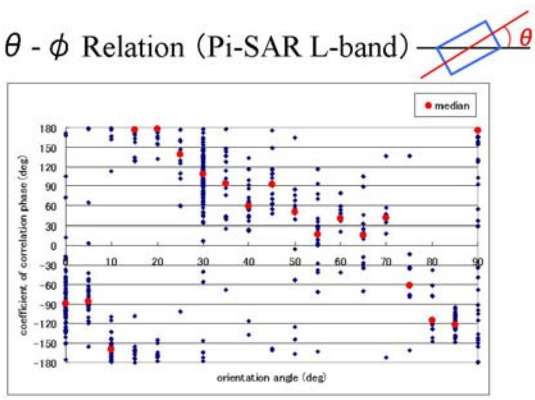
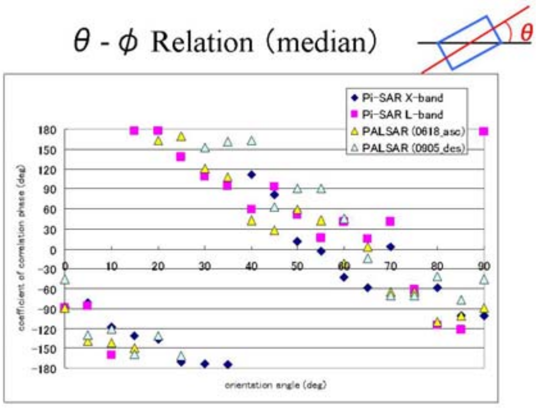


Fig.6 θ - ϕ relation in PiSAR(L-band) case



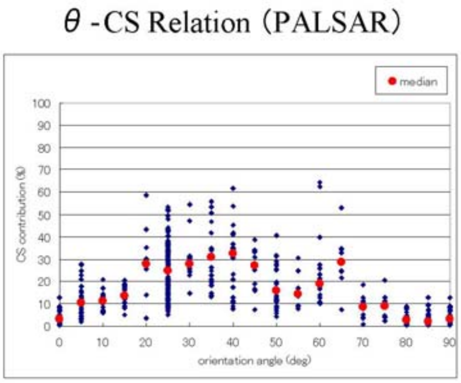
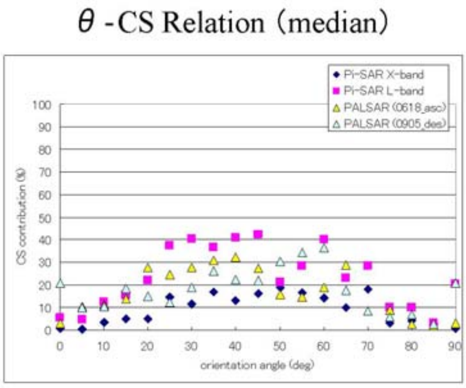


Fig.7 θ - ϕ (median) relation in several POLSAR cases

Fig.8 θ - CS relation in PALSAR case



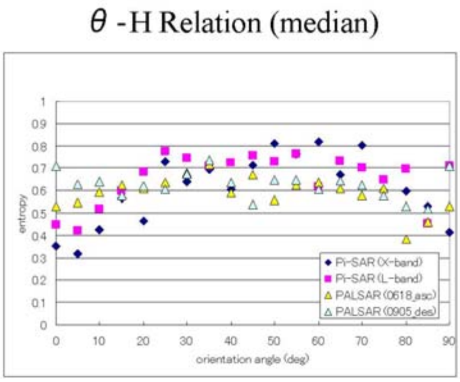
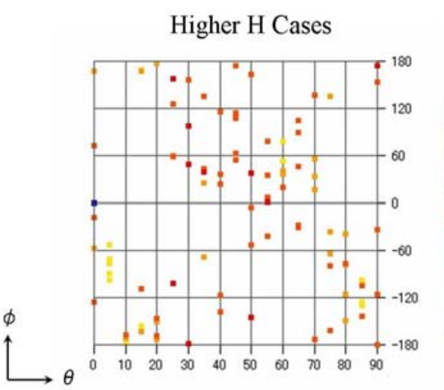


Fig.9 θ - CS(median) relation in several POLSAR cases

Fig.10 θ - H (median) relation in several POLSAR cases



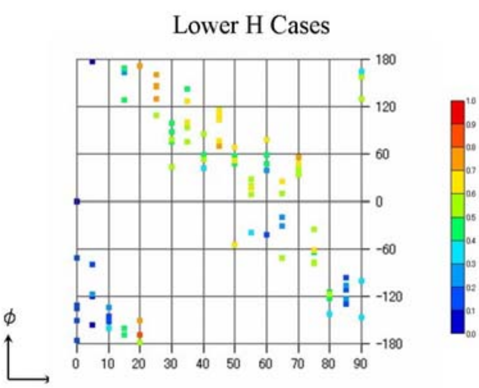


Fig.11 θ - ϕ relation in PiSAR(L-band) case with higher H cases

Fig.12 θ - ϕ relation in PiSAR(L-band) case with lower H cases