第２１回 環境リモートセンシングシンポジウム

Three-Dimensional Texture in the Context of Remote Sensing Damage Detection

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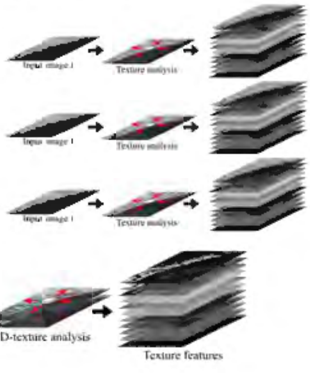
Early Motivation of This Study

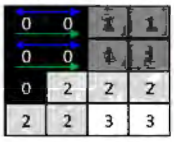
- The application of GLCM texture at each image creates a huge amount of data.
- Variation of texture are usually measured by simple differentiation, which is not completely satisfactory

Lets compute GLCM in a three dimensional domain!



Ordinary GLCM-Based Texture Features

Haralick, R. M., Shanmugam, K., Dinstein, I., Texture features for image classification, *IEEE Transactions on Systems, Man, and Cybernetics*, Vol 3, No. 6, 1973



$$P_H = \begin{pmatrix} 2 & 2 & 1 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 3 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad P_H = \begin{pmatrix} 4 & 2 & 1 & 0 \\ 2 & 4 & 0 & 0 \\ 1 & 0 & 6 & 1 \\ 0 & 0 & 1 & 2 \end{pmatrix}$$

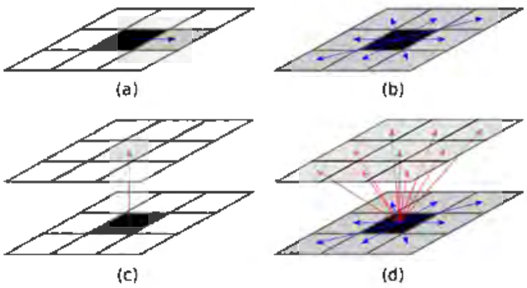
$$\text{Contrast} = \sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2 \qquad \text{Energy} = \sqrt{\text{ASM}}$$

$$\text{Dissimilarity} = \sum_{i,j=0}^{N-1} P_{i,j}|i-j| \qquad \text{Entropy} = \sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j})$$

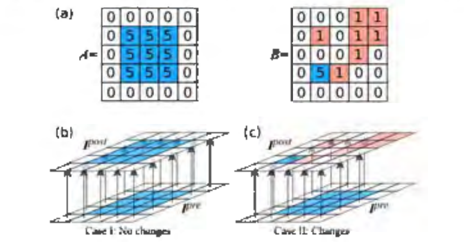
$$\text{Homogeneity} = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \qquad \mu_i = \sum_{i,j=0}^{N-1} i(P_{i,j}) \qquad \mu_j = \sum_{i,j=0}^{N-1} j(P_{i,j})$$

$$\text{ASM} = \sum_{i,j=0}^{N-1} P_{i,j}^2 \qquad r = \sum_{i,j=0}^{N-1} P_{i,j}\left[\frac{(i-\mu_i)(j-\mu_j)}{\sqrt{\sigma_i^2\sigma_j^2}}\right]$$

3DGLCM: Extrapolating Ideas

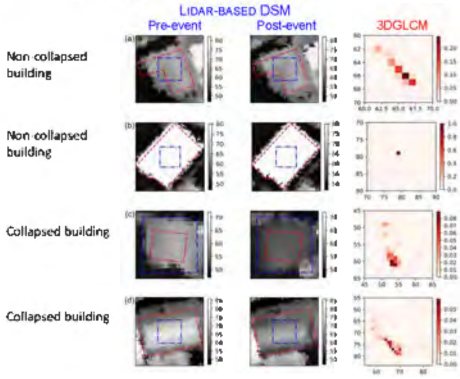


Some Insights of 3DGLCM Applied to Change Detection

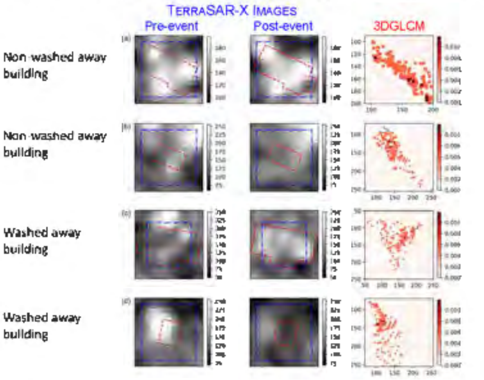


$$P^{AA} = \begin{pmatrix} 16 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 9 \end{pmatrix} \qquad P^{AB} = \begin{pmatrix} 13 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 4 & 4 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Some Real Examples: The 2016 Kumamoto Earthquake



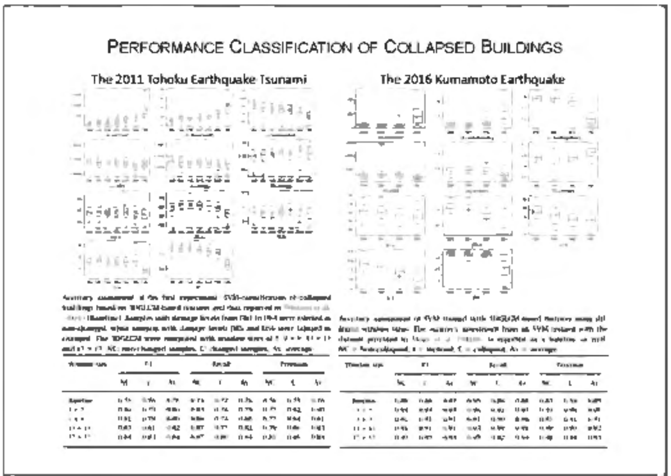
Some Real Examples: The 2011 Tohoku Earthquake and Tsunami

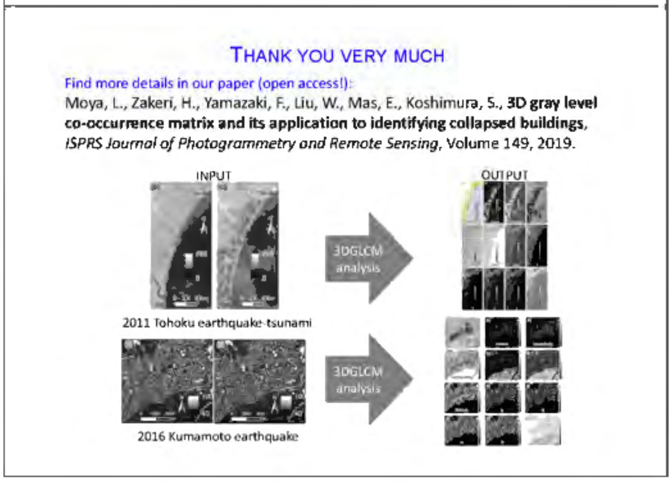


3DGLCM-Based Features

$$\text{Contrast} = \sum_{i,j=0}^{N-1} p_{i,j}(i-j)^2 \qquad \text{ASM} = \sum_{i,j=0}^{N-1} p_{i,j}^2$$

Feature	Samples from the TerraSAR-X				Samples from the Lidar data			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
Contrast	163.30	422.99	2039.85	2314.00	0.27	0.00	31.15	79.64
Dissimilarity	[illegible]	16.09	39.70	33.91	0.25	0.00	5.08	6.76
Homogeneity	0.13	0.05	0.02	0.05	0.88	1.00	0.11	0.02
ASM	0.01	0.01	0.01	0.01	0.15	1.00	0.04	0.03
Energy	0.06	0.06	0.06	0.08	0.37	1.00	0.20	0.17
Entropy	5.07	5.11	5.41	5.11	2.92	0.50	3.53	3.76
μ_i	153.46	143.96	130.47	151.16	[illegible]	79.00	57.78	74.36
μ_j	156.45	142.57	156.00	120.67	65.12	79.00	53.26	65.62
σ_i	23.13	56.36	20.07	43.05	1.54	0.30	3.73	[illegible]
σ_j	26.44	26.46	30.30	19.38	1.55	0.60	1.67	7.43
ρ	0.86	0.65	0.00	0.51	0.45		0.48	0.09


PERFORMANCE CLASSIFICATION OF COLLAPSED BUILDINGS
The 2011 Tohoku Earthquake Tsunami
The 2016 Kumamoto Earthquake


THANK YOU VERY MUCH
Find more details in our paper (open access!):
Moya, L., Zakeri, H., Yamazaki, F., Liu, W., Mas, E., Koshimura, S., 3D gray level co-occurrence matrix and its application to identifying collapsed buildings, ISPRS Journal of Photogrammetry and Remote Sensing, Volume 149, 2019.
INPUT
OUTPUT
3DGLCM analysis
2011 Tohoku earthquake-tsunami
3DGLCM analysis
2016 Kumamoto earthquake