NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

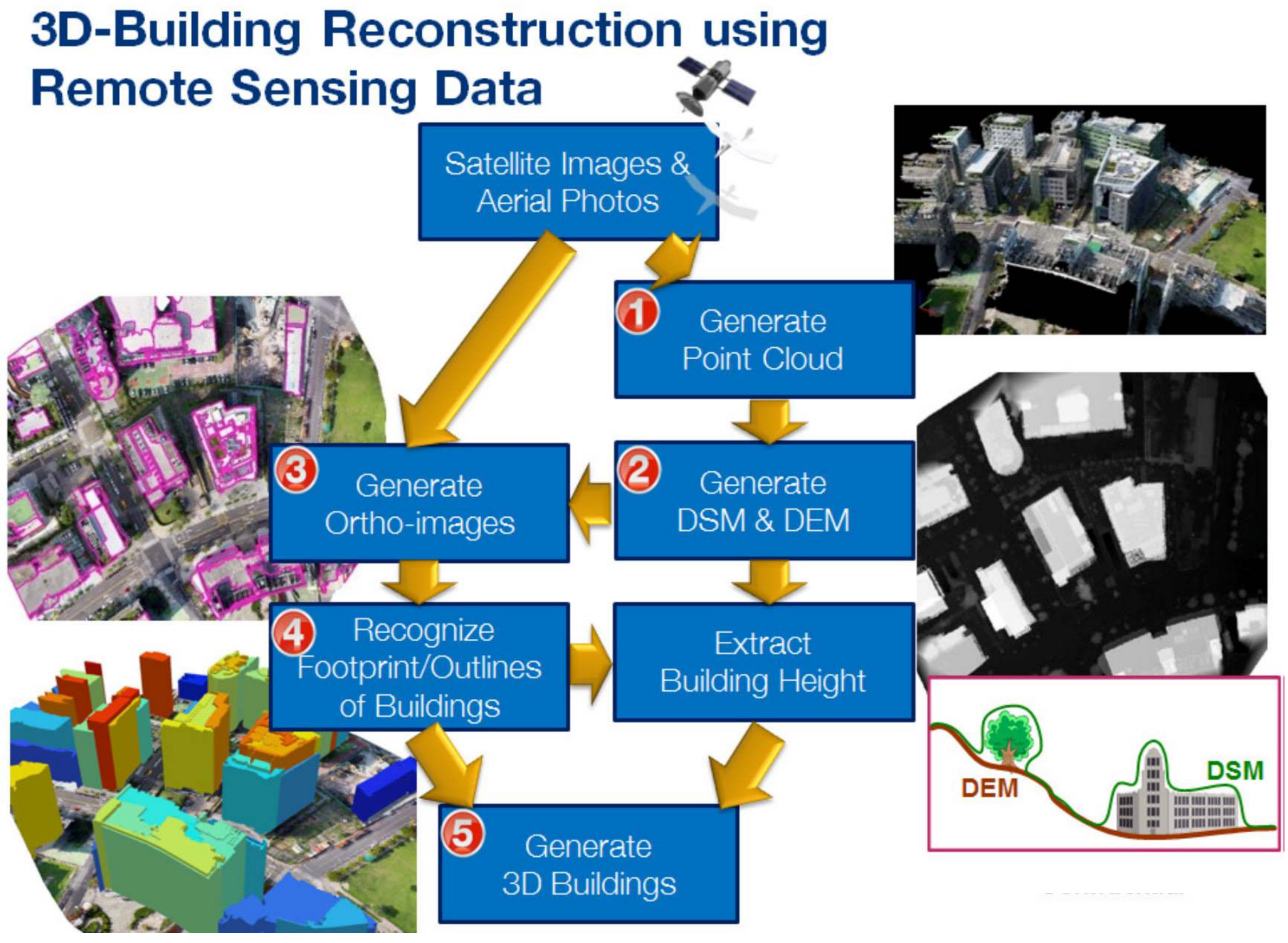
Institute of Catastrophe Risk Management

Automatic Urban Building Area and Height Extraction using High Resolution Satellite Imagery – Taipei, Jakarta & Bangkok

Edmond Y.M. Lo, Tso-Chien Pan and **V. Daksiya**
Institute of Catastrophe Risk Management, NTU, Singapore

Kuo-Shih Shao, En-Kai Lin, Yi-Rung Chuang and **Kuan-Yi Lee**
Disaster Prevention Technology Research Center
Sinotech Engineering Consultants, Inc., Taipei, Taiwan

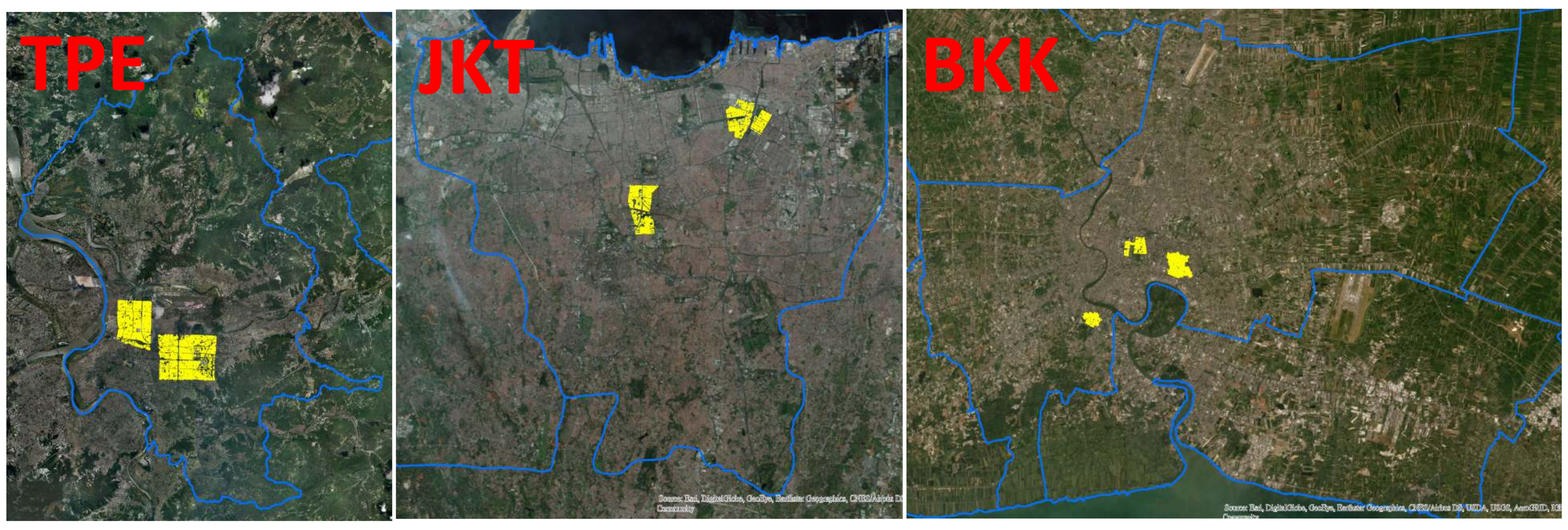
3D-Building Reconstruction using Remote Sensing Data



- Asia has the largest growth of real assets, and for 2017, 21 of the world's 35 megacities are located in Asia
- Asia has historically suffered the most from catastrophic (Cat) events, but has the least amount of safety net or risk transfer mechanisms
- While insurance industry could significantly contribute in mitigating the impact of natural catastrophes, effective Cat risk financing solutions need robust models and data, including exposure data models, to quantify the Cat risk
- This effort aims to develop a high resolution exposure model (geometric characteristics) of building structures in cities via high resolution satellite imagery
- The image processing incorporating a high degree of automation is demonstrated for Taipei (TPE), Jakarta (JKT) and Bangkok (BKK)

Building Footprint & Height Extraction

Input	Purpose	Output
DSM(Digital Surface Model) DEM(Digital Elevation Model)	Generate OHM(Object Height Model) from DSM-DEM	Building footprint via segmentation on Object Height Model (OHM) or ortho-image (for low buildings).
Multispectral satellite image	Generate NDVI (Normalized Difference Vegetation Index) to filter out vegetation area	
Open Street Map road data	Generate road buffer to filter out road area	Building height via OHM values over extracted building footprint
Ortho-rectified Image	Building footprint for low bldgs	



Classification Results: Extracted Polygons vs Ground Truth

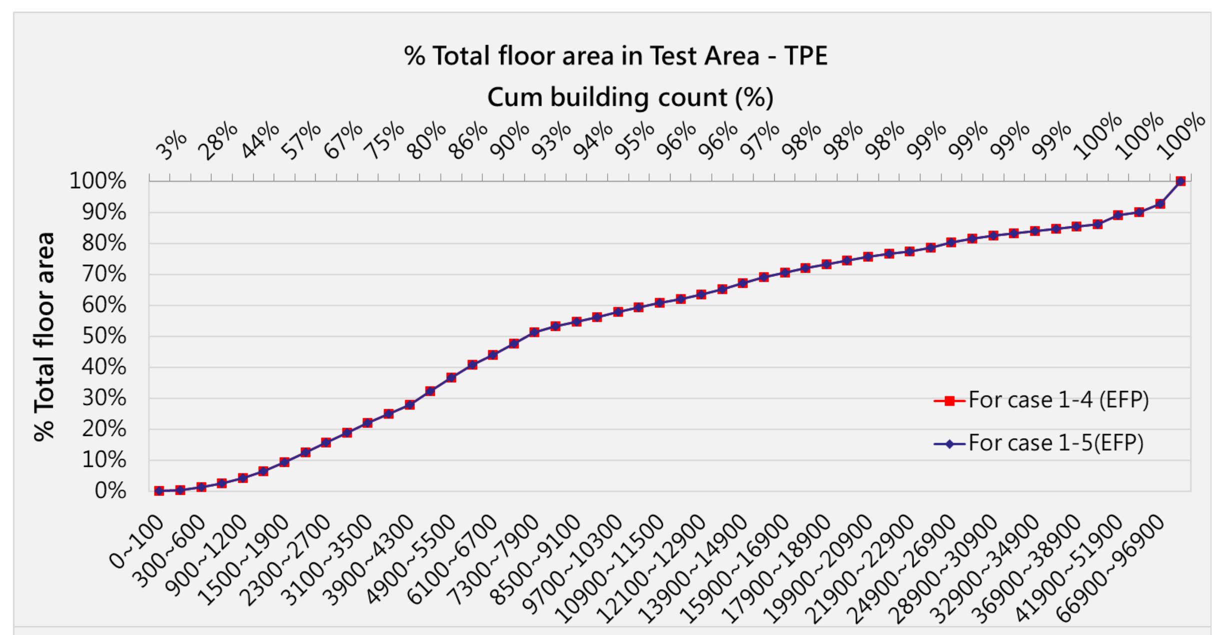
- Larger polygons with larger Total Floor Area (TFA) well extracted with Case 2 (one-to-one) classification at 70% and Mean Absolute Error in TFA at <18%
- Case 3 (1 extracted to multiple) further corresponds to closely spaced buildings which are very similar in height and structurally, and thus in vulnerability

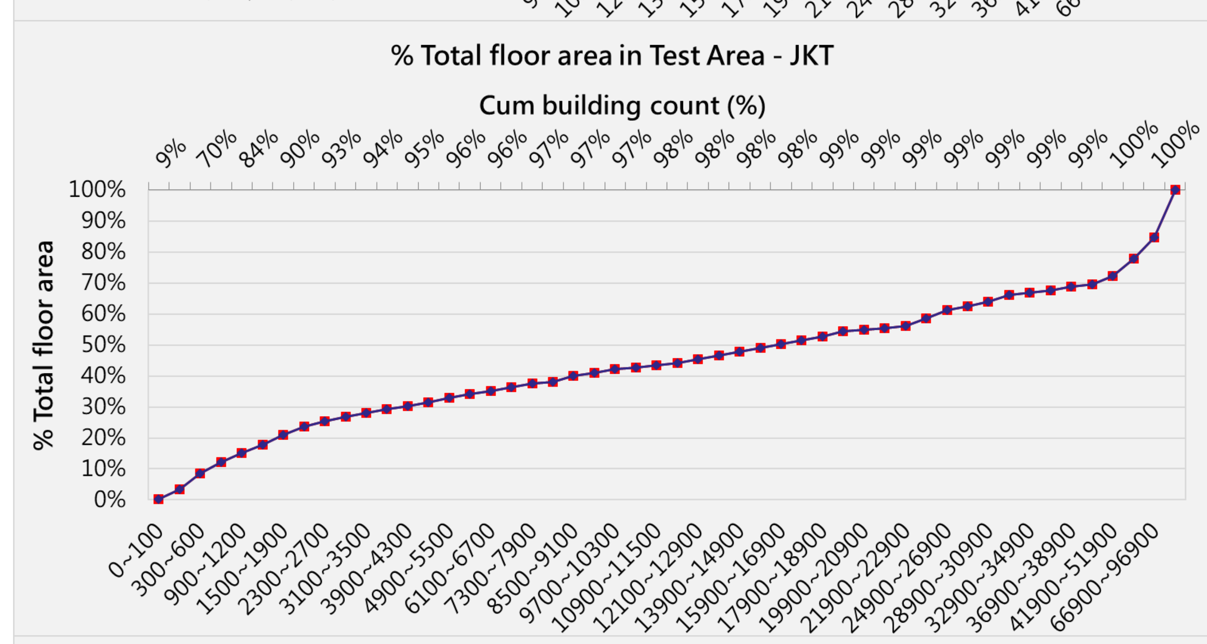
Case	Description
Case 1	1 to 0 (extra)
Case 2	1 to 1
Case 3	1 extracted to multiple
Case 4	Multiple extracted to 1
Case 5	0 to 1 (missed)
Total No. of extracted BFT	

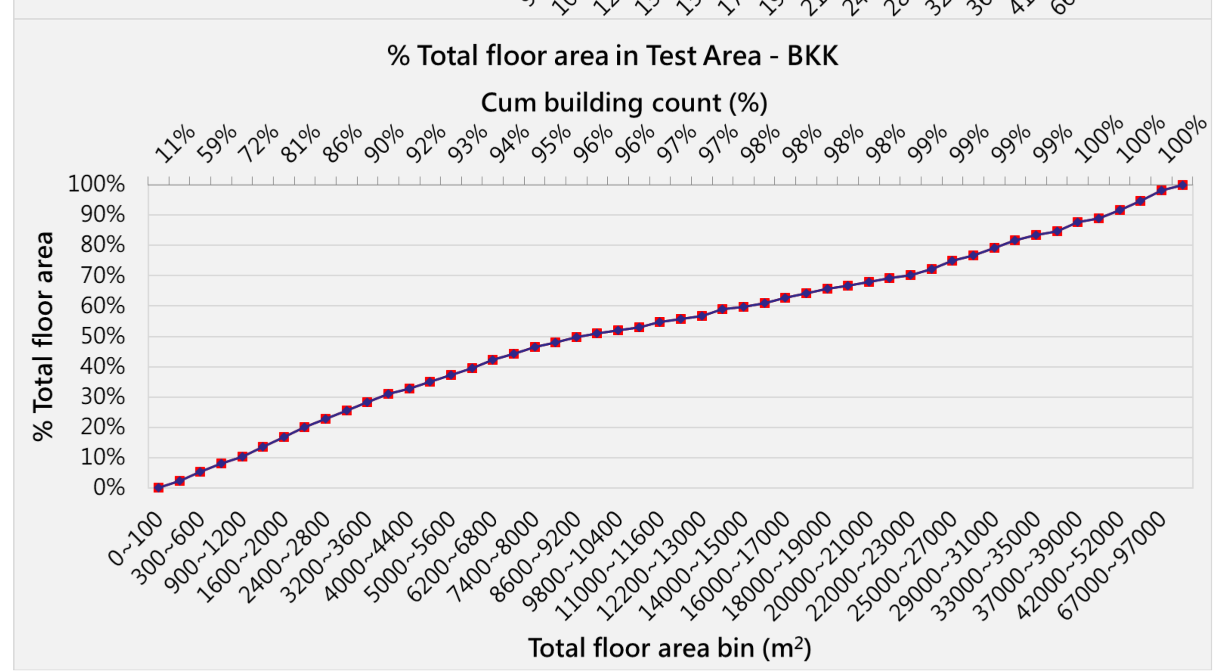
Taipei	TFA < 8,000m²	TFA 8,000 - 16,000m²	TFA ≥ 16,000m²
MAE in TFA	<42%	<18%	<15%
Coeff of Variance	<1.3	<2.7	1.6
% of Case 2	50%	70%	75%
% of polygons	92%	5%	3%
Jakarta	**TFA < 2,500m²**	**TFA 2,500 - 8,000m²**	**TFA ≥ 8,000m²**
MAE in TFA	<50%	<31%	<23%
Coeff of Variance	<1.0	<4.7	<4.0
% of Case 2	50%	85%	85%
% of polygons	92%	5%	4%
Bangkok	**TFA < 4,000m²**	**TFA 4,000 - 8,000m²**	**TFA ≥ 8,000m²**
MAE in TFA	<57%	<22%	<18%
Coeff of Variance	<1.3	<1.8	2.2
% of Case 2	56%	74%	75%
% of polygons	88%	6%	6%

Extracted (yellow) and Taipei Vector Data (ground truth, red)

Average storey height of 3.45m is used to convert height to no of storeys in TFA calculation.







Summary

- Larger buildings comprise ~10% of building count and 45%, 75% & 70% of the total TFA for TPE, JKT & BKK respectively. These building are well captured by the developed image processing.
- Small building comprise bulk of building count (~90%) and 55%, 25% & 30% of the TFA of all buildings for TPE, JKT & BKK respectively and are less well captured.
- Simulation using portfolios comprising all the buildings as reflecting observed count and TFA distributions show that the portfolio mean TFA error is <4% (CV <1), <7% (CV<1.4) & <6% (CV <1) for TPE, JKT & BKK respectively.
- The developed exposure building model thus well represents building portfolio values suitable for insurance purposes.

Contact Us:
Executive Director, ICRM (ExecDir-ICRM@ntu.edu.sg)
N1-B1b-07, 50 Nanyang Avenue, Singapore 639798
Tel: +65 6592 1866 Website: http://icrm.ntu.edu.sg

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