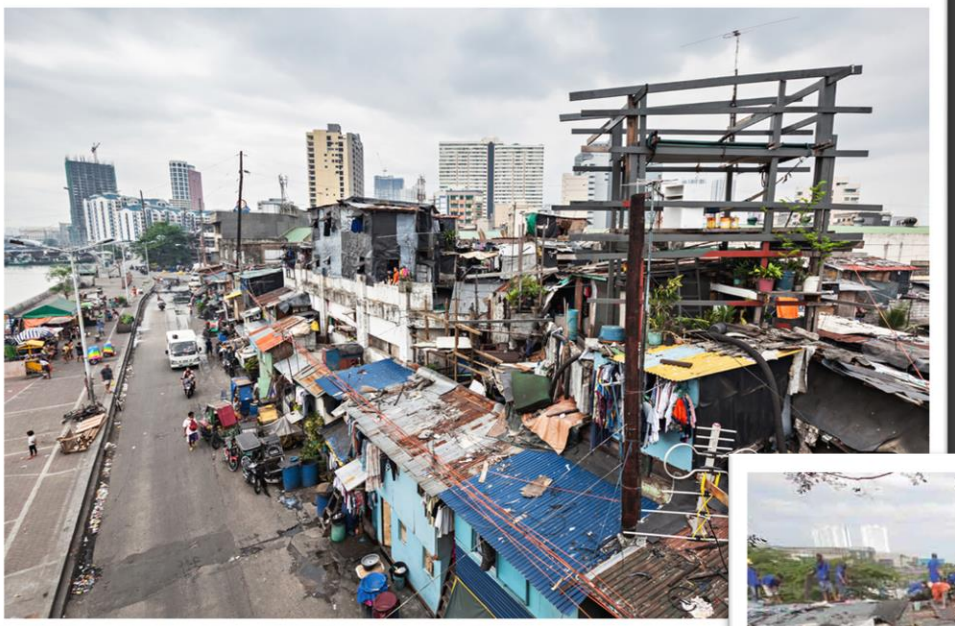
SETTLEMENT CLASSIFICATION OF REMOTELY-SENSED IMAGES USING MULTI-SCALE BLOCK LOCAL BINARY PATTERN

Robin Joshua P. Gagpanan
Rizza DC. Mercado



http://www.canadianinquirer.net/wp-content/uploads/2014/06/squatters-informal-settlers-poverty-manila.jpg
https://sa.kapamilya.com/absnews/abscbnnews/media/2019/news/04/03/20140128_squatter_demolition-rtr.jpg

Background of the Problem

- current research on settlement classification mostly in foreign countries
- only a few were written in the Philippine context
- growth in informal settlements in the country
- a method to classify formal and informal settlements is explored

Significance of the Study

- represent physical demographics of informal settlements
- aid decision-makers to deal with settlement-related issues
- initial step towards developing other programs and applications

Research Objectives

This study aims to develop a program that can classify settlements using satellite images from Google Earth. Specifically, the study aims to accomplish the following:

1. Collect formal and informal settlement areas from Google Earth;
2. Build a training data set of formal and informal settlements;
3. Extract MB-LBP feature on each type of settlement,
4. Classify formal between informal settlements, and;
5. Evaluate the performance of MB-LBP in classifying settlements.

Scope and Limitation

- satellite images from Google Earth
- Metro Manila area taken from a zoom of 100m.
- image resolution of training images: 320 x 180
  testing images: 1980 x 1080
- true class of settlements was based from research article of Taubenböck et al. (2018)

Methodology

- Materials
  - Windows 10 Home Single Licence
  - Text editor software
  - Python (programming language) software Version 3.7.3
  - OpenCV library version 4.1.1
  - Google Earth desktop application

Methodology

- Image Acquisition

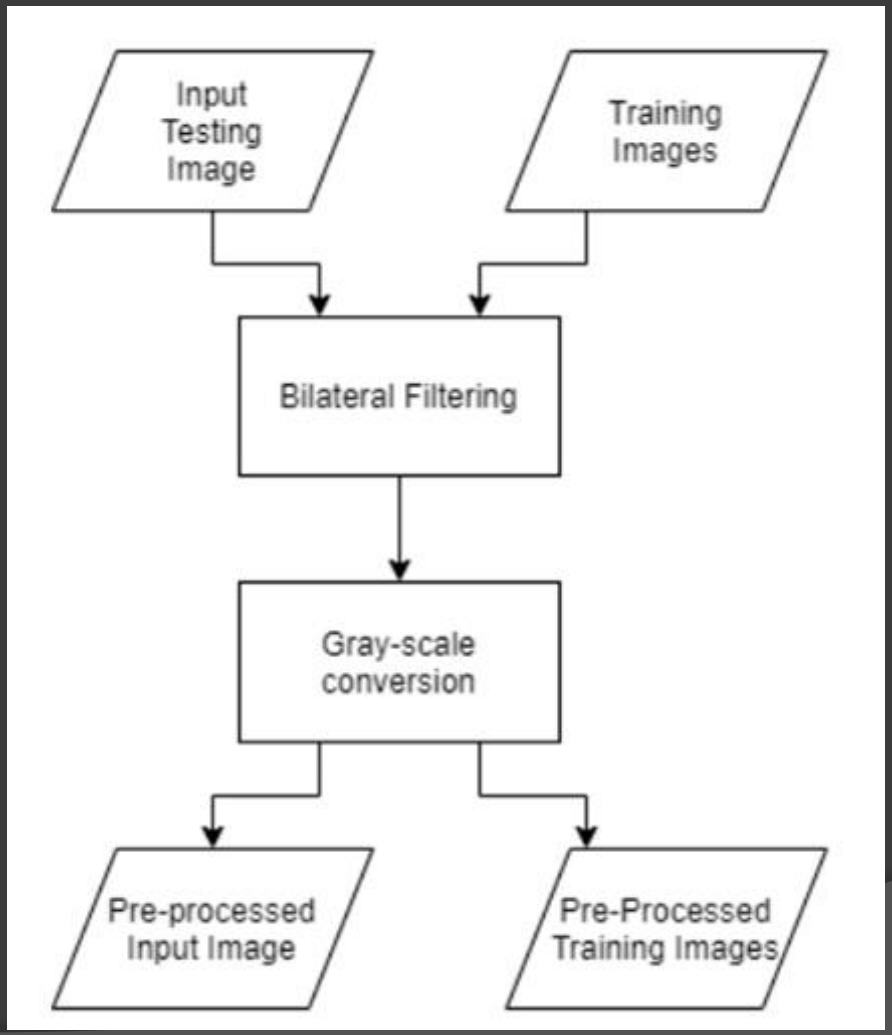
Formal Settlements

Informal Settlements

Sample input image for classification

Methodology

- Image Pre-processing



Methodology

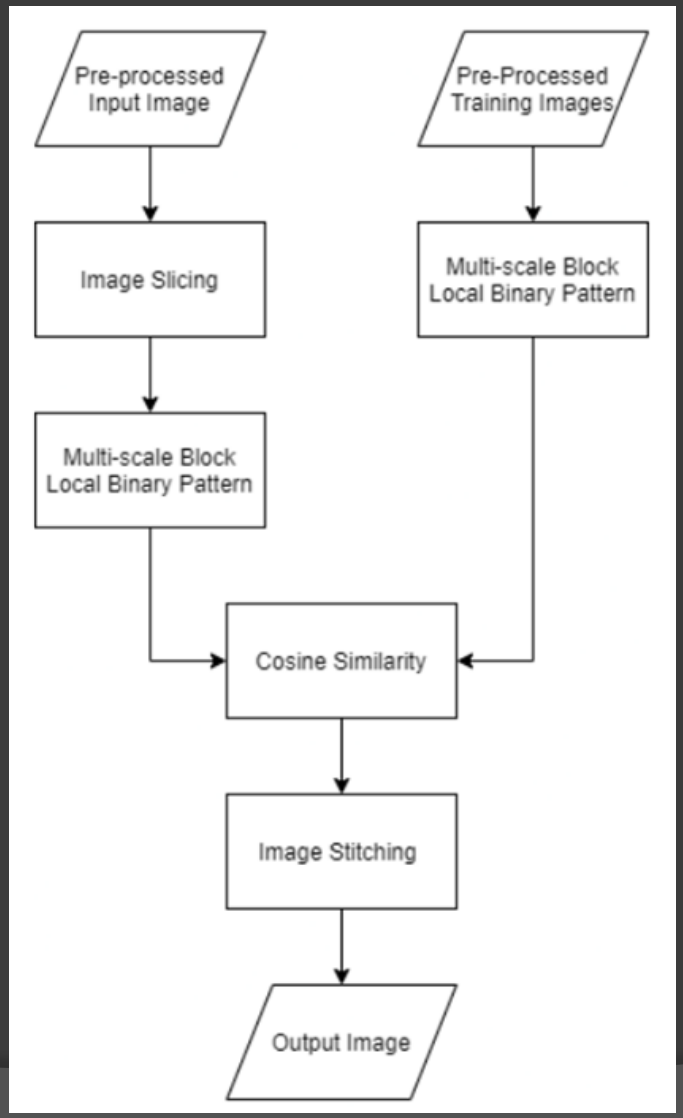
- Image Pre-processing

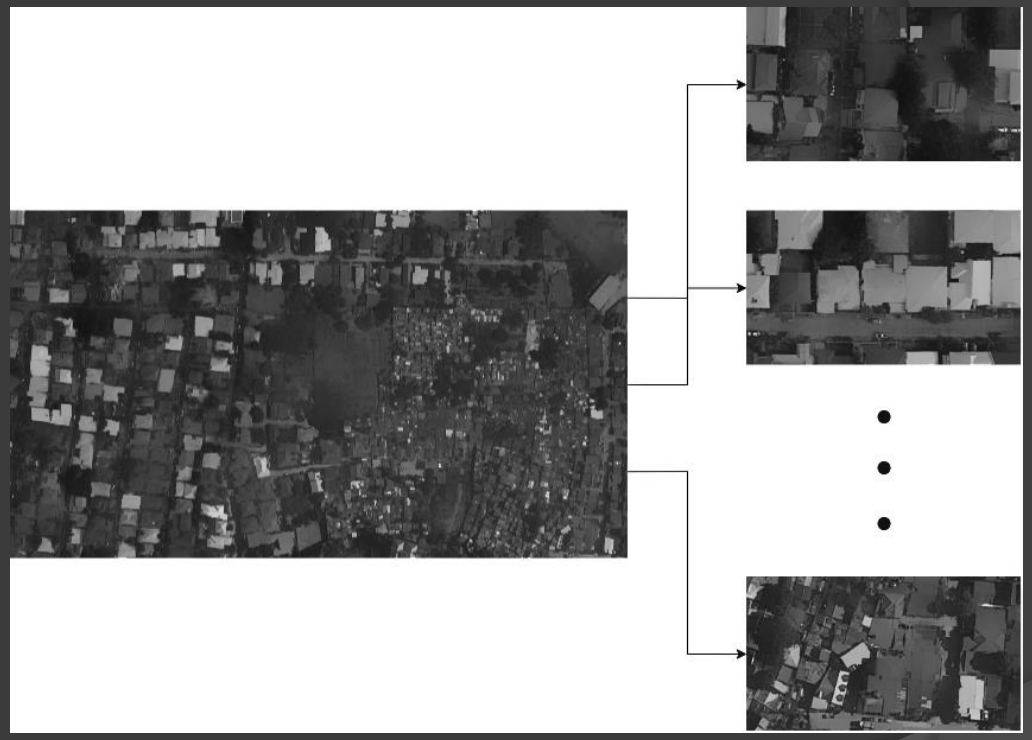
Settlement Images Before Image Pre-processing

Settlement Images After Image Pre-processing

Methodology

- Image Analysis

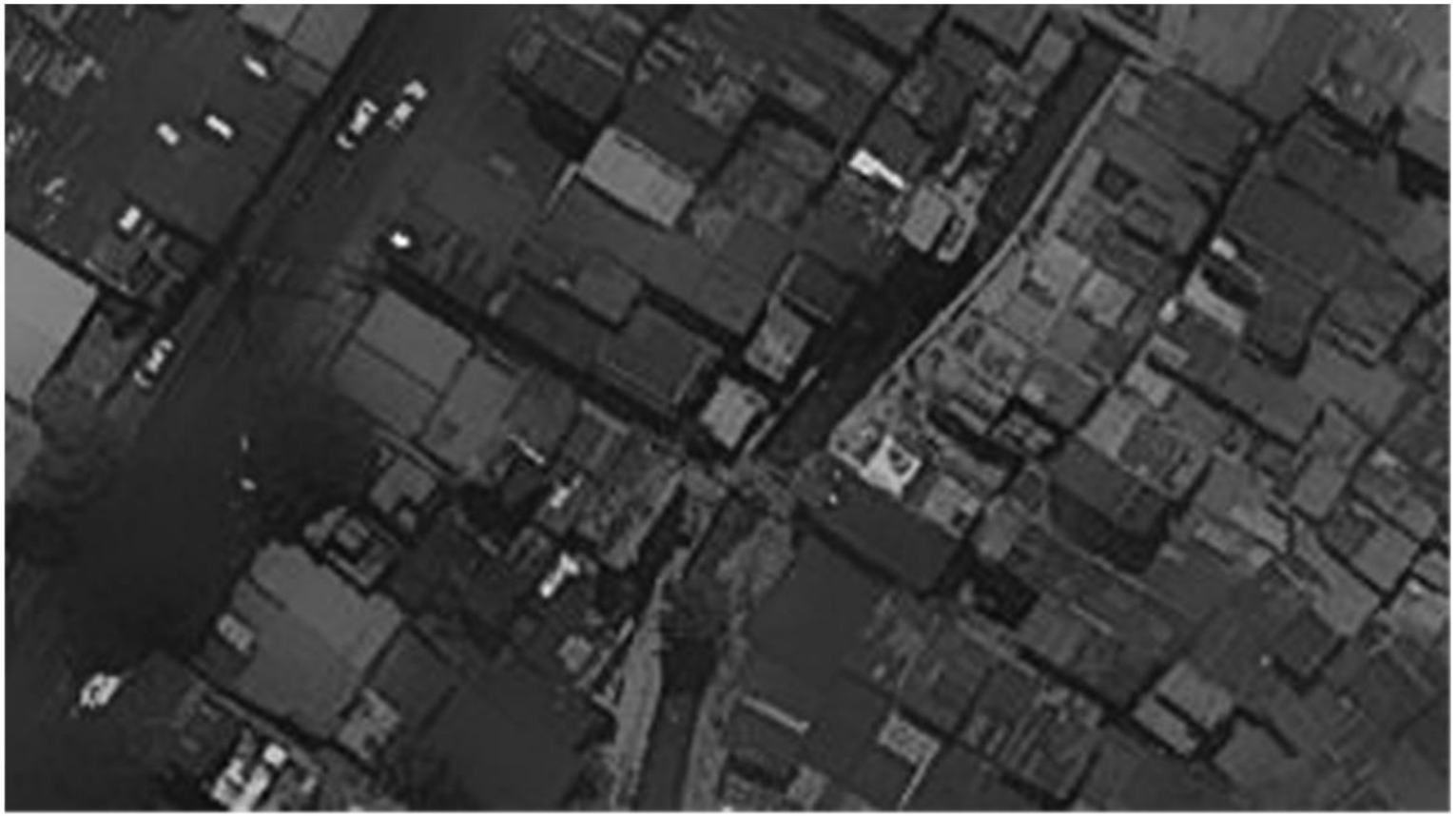




Testing Image Transformed Into Sliced Images

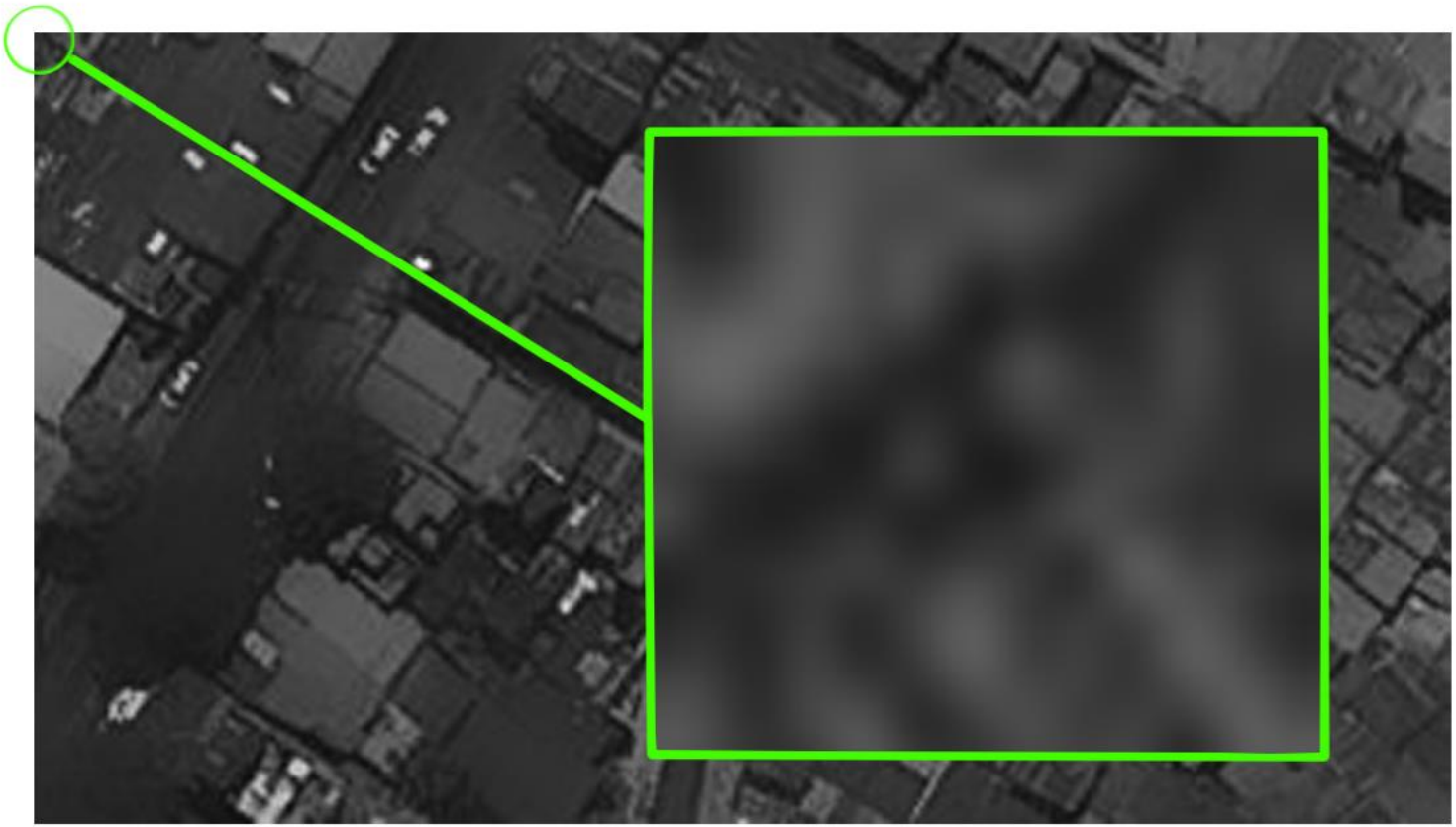
Methodology

- Image Analysis



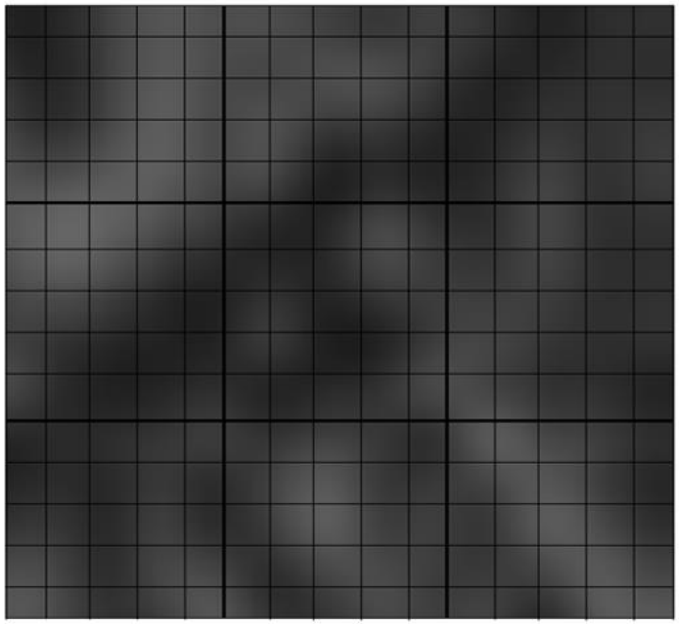
Methodology

- Image Analysis



Methodology

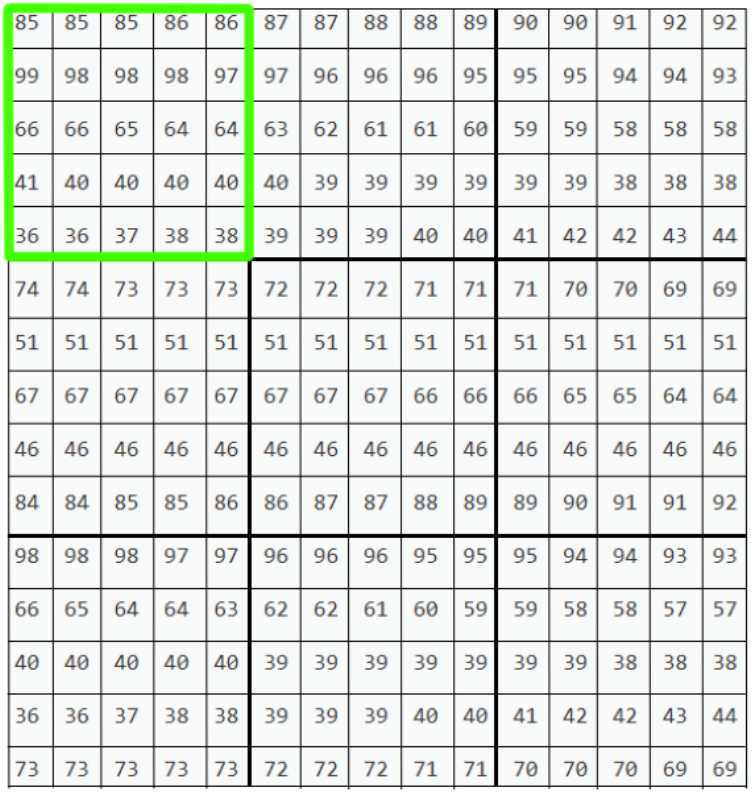
- Image Analysis



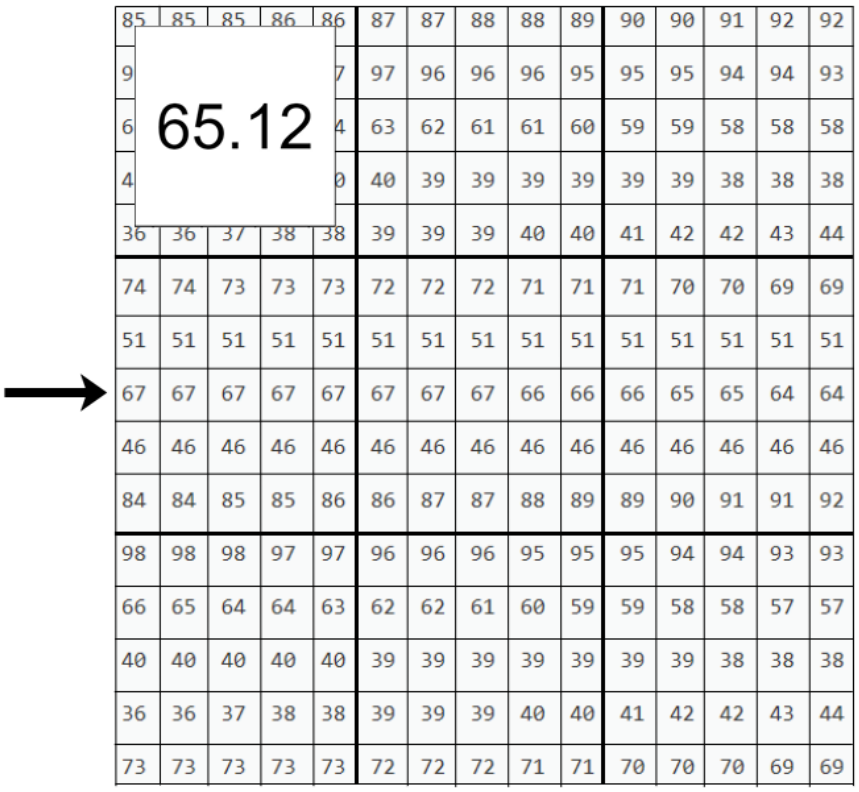
85	85	85	86	86	87	87	88	88	89	90	90	91	92	92
99	98	98	98	97	97	96	96	96	95	95	95	94	94	93
66	66	65	64	64	63	62	61	61	60	59	59	58	58	58
41	40	40	40	40	40	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
74	74	73	73	73	72	72	72	71	71	71	70	70	69	69
51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
67	67	67	67	67	67	67	67	66	66	66	65	65	64	64
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
84	84	85	85	86	86	87	87	88	89	89	90	91	91	92
98	98	98	97	97	96	96	96	95	95	95	94	94	93	93
66	65	64	64	63	62	62	61	60	59	59	58	58	57	57
40	40	40	40	40	39	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
73	73	73	73	73	72	72	72	71	71	70	70	70	69	69

Methodology

- Image Analysis



85	85	85	86	86	87	87	88	88	89	90	90	91	92	92
99	98	98	98	97	97	96	96	96	95	95	95	94	94	93
66	66	65	64	64	63	62	61	61	60	59	59	58	58	58
41	40	40	40	40	40	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
74	74	73	73	73	72	72	72	71	71	71	70	70	69	69
51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
67	67	67	67	67	67	67	67	66	66	66	65	65	64	64
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
84	84	85	85	86	86	87	87	88	89	89	90	91	91	92
98	98	98	97	97	96	96	96	95	95	95	94	94	93	93
66	65	64	64	63	62	62	61	60	59	59	58	58	57	57
40	40	40	40	40	39	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
73	73	73	73	73	72	72	72	71	71	70	70	70	69	69

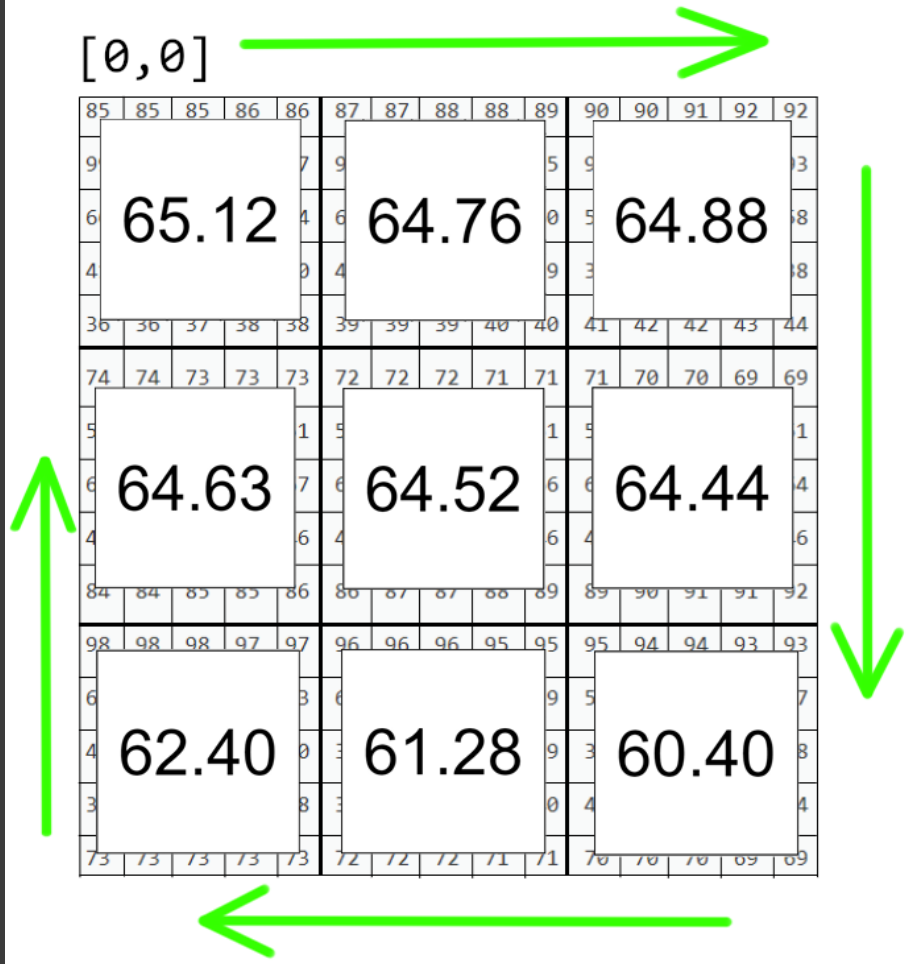


85	85	85	86	86	87	87	88	88	89	90	90	91	92	92
9				7	97	96	96	96	95	95	95	94	94	93
6				4	63	62	61	61	60	59	59	58	58	58
4				0	40	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
74	74	73	73	73	72	72	72	71	71	71	70	70	69	69
51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
67	67	67	67	67	67	67	67	66	66	66	65	65	64	64
46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
84	84	85	85	86	86	87	87	88	89	89	90	91	91	92
98	98	98	97	97	96	96	96	95	95	95	94	94	93	93
66	65	64	64	63	62	62	61	60	59	59	58	58	57	57
40	40	40	40	40	39	39	39	39	39	39	39	38	38	38
36	36	37	38	38	39	39	39	40	40	41	42	42	43	44
73	73	73	73	73	72	72	72	71	71	70	70	70	69	69

$$\frac{85 + 85 + 85 + 86 + 86 + 99 + 98 + 98 + 98 + 97 + 66 + 66 + 65 + 64 + 64 + 41 + 40 + 40 + 40 + 40 + 36 + 36 + 37 + 38 + 38}{25} = 65.12$$

Methodology

- Image Analysis

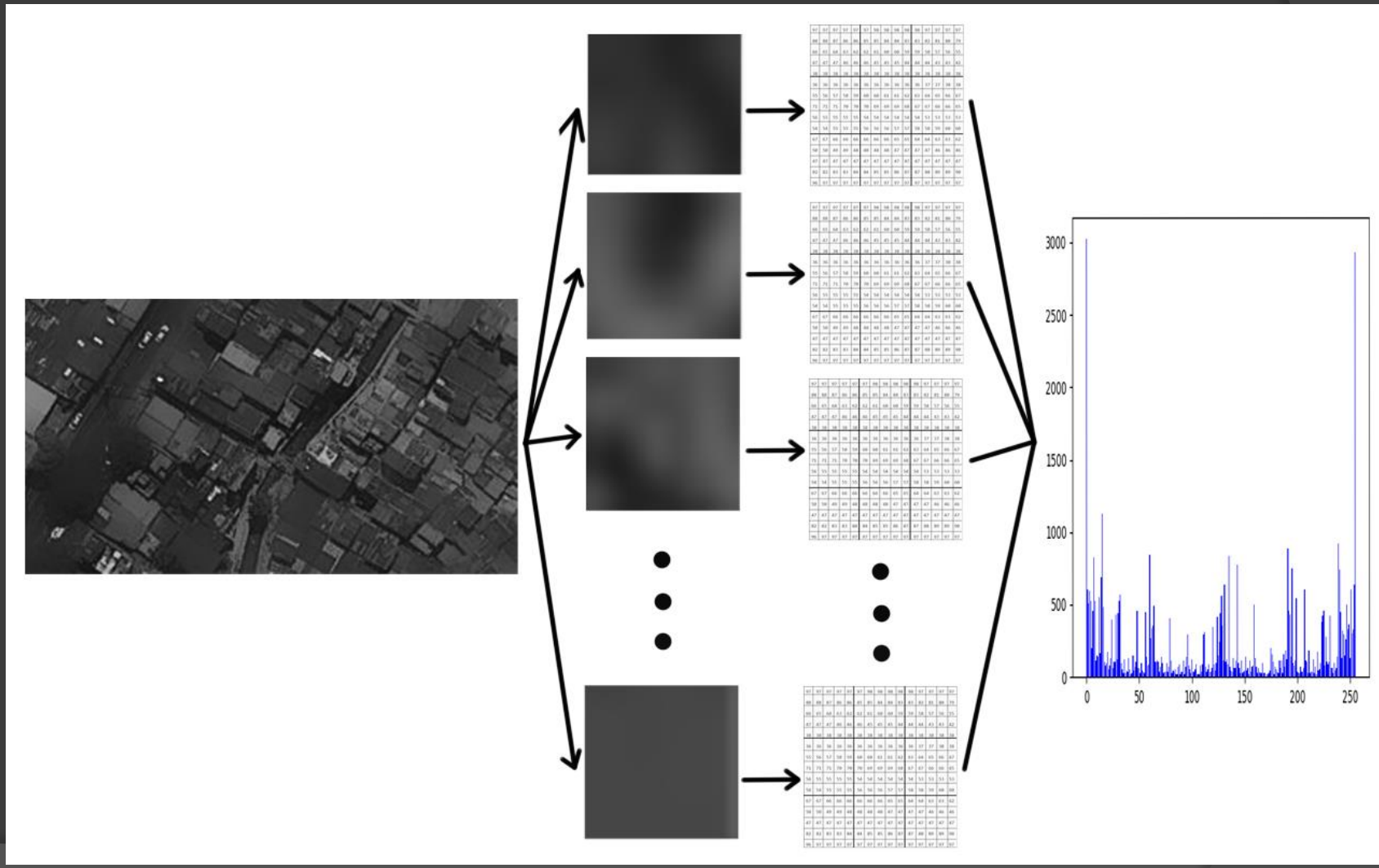


64.52 > 65.12 ? ... 1
64.52 > 64.76 ? ... 1
64.52 > 64.88 ? ... 1
64.52 > 64.44 ? ... 0
64.52 > 60.40 ? ... 0
64.52 > 61.28 ? ... 0
64.52 > 62.40 ? ... 0
64.52 > 64.63 ? ... 1

MB-LBP value
11100001 = 225

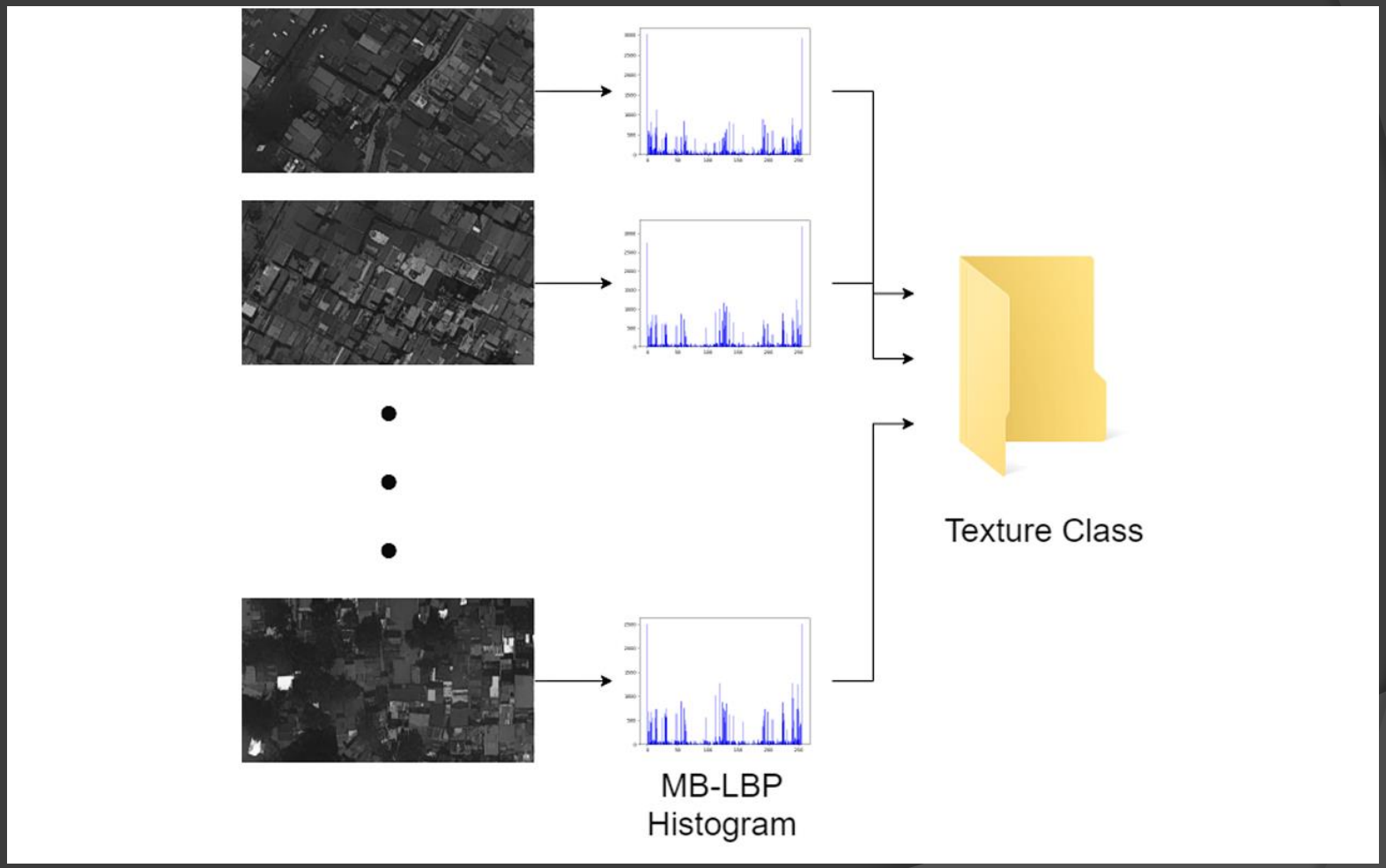
Methodology

- Image Analysis



Methodology

- Image Analysis



Images are Converted to a MB-LBP Histogram and Stored as a Texture Class

Methodology

- Image Analysis

$$\cos(\theta) = \frac{A \cdot B}{\|A\|\|B\|} = \frac{\sum_{i=1}^{n} \mathbf{A}_i \mathbf{B}_i}{\sqrt{\sum_{i=1}^{n} \mathbf{A}_i^2} \sqrt{\sum_{i=1}^{n} \mathbf{B}_i^2}}$$

Settlement Classified as Formal (Green) and Informal (Red)

Methodology

- Image Analysis - Stitching

Results and Discussion

	Predicted Positive	Predicted Negative
Actual Positive	**True Positive (TP)** - Informal Classified as Informal **TP = 69**	**False Negative (FN)** - Formal Classified as Informal **FN = 7**
Actual Negative	**False Positive (FP)** - Informal Classified as Formal **FP = 2**	**True Negative (TN)** - Formal Classified as Formal **TN = 102**

$$Precision = \frac{TP}{TP+FP}$$

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN}$$

Classification Precision				
Images	3x3	9x9	15x15	21x21
1	0.9091	1.0000	0.9091	1.0000
2	0.8824	0.9412	0.9412	0.8824
3	0.8333	1.0000	1.0000	1.0000
4	0.9231	1.0000	1.0000	0.9231
5	0.5000	1.0000	1.0000	0.8333
TOTAL	0.7887	0.9859	0.9718	0.9154

Classification Precision Obtained with Various Sub-window Sizes

Classification Accuracy				
Images	3x3	9x9	15x15	21x21
1	0.9167	0.8889	0.9167	0.9444
2	0.9444	0.8889	0.9722	0.9444
3	0.9444	0.8889	1.0000	1.0000
4	0.8056	0.7778	0.8611	0.8889
5	0.7500	0.8889	0.9722	0.8889
TOTAL	0.8722	0.8667	0.9500	0.9333

Classification Accuracy Obtained with Various Sub-window Sizes

Results and Discussion (Misclassification)

Open Areas

Informal Classified as Formal

Summary and Conclusion

- The research proposed MB-LBP texture features as classifier to categorize formal and informal settlements.
- The texture feature used have already considered the density, housing quality and the house size, it does not need to be computed separately as additional features to be used for classification.
- This study has shown that 15x15 sub-windows has the optimal values for accuracy (95.00%) and precision (97.18%).