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Urban Built-up Change Detection with Minimum Redundancy Maximum Relevance Approach

Kyi Thar Oo[1*], Khin Myo Kyi[2], Zarli Cho[3]

[1]University of Computer Studies, Thaton, Myanmar
[2]University of Computer Studies, Taungoo, Myanmar
[3]University of Computer Studies, Taungoo, Myanmar

[*]*Corresponding Author: kyitharoo752@gmail.com*

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Abstract— Urban built-up area information is required in various applications of land use planning and management. Urban environment is made up with the complex interactions with built up environment and the human communities living within the urban area. The aim of the system is to assess an effective building change detection system that can identify gains and losses of built-up areas in relation to other land cover of Multi-temporal satellite image of Mandalay city in Myanmar. The proposed system apply to combine with gray level histogram features with minimum redundancy maximum relevance (MRMR) approach for built-up change detection system. The experimental analysis revealed that the proposed system combination with histogram features based on MRMR which is more reliable in urban built-up change detection system.

Keywords—MRMR, Hitogram feature,classification, detection

I. INTRODUCTION

The land resource is one of the most important resources for human beings. Many things in reality have dual characters, so does urbanization. One of the most significant characteristic of urbanization is that the proportion of urban population to total population is increasing. One of the effects of expansion of population is the expansion of urban area, so the surrounding natural environment is destroyed, such as the deforestation.

Due to the environmental issues resulting from the high speed urbanization, building detection has received increasing attention in recent years in Myanmar. Automatic building detection from monocular optical images is a challenging pattern recognition problem, which is also the key for building change analysis. The current building detectors for high resolution images include the scale-invariant feature transform (SIFT) key-point based method [2] and shadow evidence based building reconstruction [1].

Large intraclass variance and a small interclass variance can lead to inaccuracy for the traditional spectral based and pixel based image processing framework when high-spatial-resolution imagery is used for change detection [3]. In order to deal with this problem and improve the accuracy of change detection from high-resolution data, researchers have proposed to take spatial features into consideration for change detection, e.g., the gray level co-occurrence matrix [4], wavelet transform [5], Markov random fields [6], and morphological profiles [7-8].

The aim of the system is to assess an effective building change detection system that can identify gains and losses of built-up areas in relation to other land cover of Multi-temporal satellite image of Mandalay city in Myanmar. The proposed system apply to combine with gray level histogram features with minimum redundancy maximum relevance (MRMR) approach for built-up change detection system.

The rest of the paper is classified as follows: section 2 describes the proposed system and briefly discuss the procedure of the system. Section 3 describes the related methodologies of this study and explains the analytical results in section 4.

II. PROPOSED SYSTEM OF URBAN BUILT-UP DETECTION AND DATA ACQUISITION

There is a research about urbanization in Mandalay City from Myanmar. The aims of this study is to investigate the temporal and spatial characteristics of urban expansion from 2015 to 2020. In this study, image are acquired from Google Earth. The data used in this research are from the aerial images of Google earth and study area is 873,834 square meters, geographically at 21°58′30″N 96°5′0″E Mandalay city, in Myanmar. It is a typical urban landscape of Mandalay, where dense residential and commercial areas are mixed together. Image pre-processing was to make all of the images similar therefore they can be considered to be taken at the same environmental conditions. Figure shows the Mandalay city map of Myanmar and Mandalay Aerial Image of Google earth

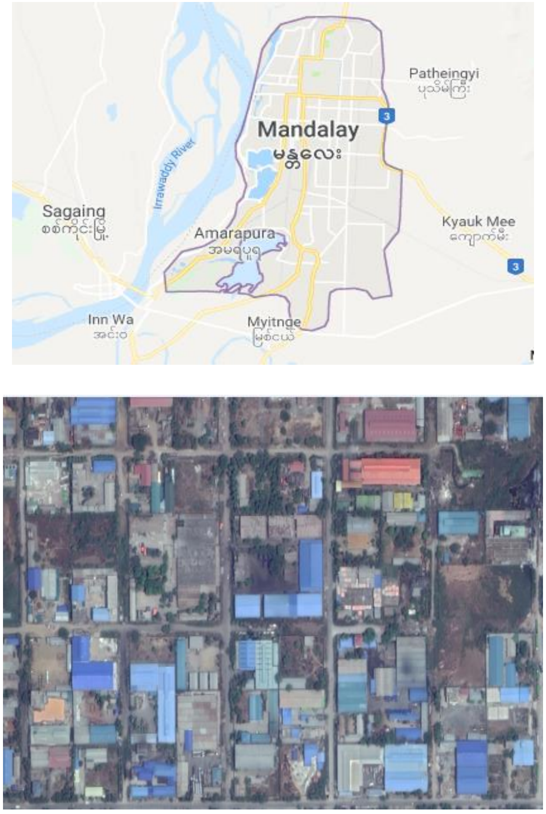

Figure 1. City map and aerial image of Mandalay, Myanmar

Figure 2 describes the proposed system of urban built-up changed detection. In this system, data are acquired from the Google earth which are resized, filtering, and segmentation in the pre-processing step. After the preprocessing step, gray level histogram are extracted from the input image. The extracted features are classified based on the proposed minimum redundancy maximum relevance (MRMR) approach. Moreover, different types of classifier are used to compare with the proposed MRMR results.

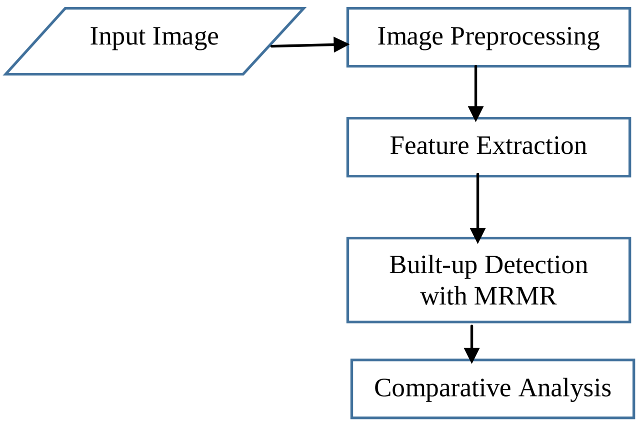

Figure2. Proposed system of urban built-up change detection

III. Related Methodology

This section describes the related methodologies of proposed system for urban built up change detection. In this study, Gray level histogram feature are extracted from tested image and applied classifier as minimum redundancy maximum relevance.

A. *Feature Extraction methods*

1) *Gray level histogram*

The aim of using the features is to obtain better feature vectors which can represent the characteristics of an image by considering statistical features of its pixels. The histogram tells us something about the distribution of the grey level. There are five aspects which will be analyzed for these features. Those aspects are mean, entropy, variance, skewness, and kurtosis of the image histogram. The mean is computed from the image histogram by using this formula:

$$\mu = \sum_{h=0}^{L-1} f_h \, p(f_h) \qquad (1)$$

where f_h =the value of intensity level
$p(f_h)$=the first-order histogram probability

Variance can be computed by using this formula:

$$\sigma^2 = \sum_{h=0}^{L-1} (f_h - \mu)^2 p(f_h) \qquad (2)$$

Skewness from an image histogram can be obtained by using this formula:

$$skew = \frac{1}{\sigma^3} \sum_{h=0}^{L-1} (f_h - \mu)^3 p(f_h) \qquad (3)$$

Kurtosis can be computed by using this formula:

$$kurtosis = \frac{1}{\sigma^4} \sum_{h=0}^{L-1} (f_h - \mu)^4 p(f_h) - 3 \qquad (4)$$

Image histogram entropy measures the shape irregularity of the histogram curve. If the image is a simple image that has a good distribution on various intensity levels, the histogram of that image will have a small kurtosis value, and vice versa.

B. *Minimum Redundancy Maximum Relevance*

The mRMR (Peng et al., 2005) is based on identifying that the integrations of individually good variables does not necessarily lead to accurate classification or prediction of performance. Peng et al. (2005) considered reducing the redundancies among the selected variables to a minimum for creating subset of variables.

To maximize the joint dependency of top-ranking variables on the target variable, the redundancy among them must be minimized, which requires incrementally selecting the maximally relevant variables while avoiding the redundant ones. In term of mutual information, the purpose of related-feature selection is to find a feature set *S* with *m* features $\{x_i\}$, which have the highest mutual information value. The maximum relevance method searches for satisfying features, which approximates *D* (*S*, *y*) in (1) between individual features x_i and class y:

$$\max D(S,y), D = \frac{1}{|S|}\sum_{x_i \in S} I(x_i; y)$$

Features selected according to maximum relevance are likely to be highly redundant, (i.e., the dependency among these features is likely to be high). When two features depend highly on each other, the respective class-discriminative power would not change much if one of them were removed [9,10]. Therefore, the following minimal redundancy (min-redundancy) condition can be added to select mutually exclusive features:

$$\min R(S), R = \frac{1}{|S|^2}\sum_{x_i, x_j \in S} I(x_i, x_j)$$

The criterion combining the above two constraints is called “minimum redundancy maximum relevance” method (mRMR). The operator $\emptyset(D,R)$ combines *D* and *R* and considers the following simplest form to optimize *D* and *R* simultaneously:

$$\max \emptyset(D,R), \emptyset = D - R$$

The aim of the objective is to find a set of optimum feature which has the highest mutual information on the explanatory and the response features are maximized and the mutual information among the explanatory features are minimized. Which is used for classifier for detection system for urban built up change.

IV. Results and Discussion

This study aim to assess an effective building change detection system that can identify gains and losses of built up areas in relation to other land cover of Multi-temporal satellite images. Moreover, the proposed system have to assist the decision makers for sustainable land planning and management that estimates the impacts of infrastructure measures. The proposed system will examine any selected region of pair images with different time series. Firstly, gray level histogram features such as skewness, kurtosis etc., are extracted from the tested image. The sample features are shown in the following table 1.

Table 1. Sample Histogram Features

No of Image	**Histogram Features**				
Image1	4.594094	1.426215	0.255396	2.819497	…….
Image2	4.890777	0.610155	-0.24726	3.108077	…….
Image3	4.886546	0.6995	-0.20464	2.89042	…….
Image4	4.290829	2.013864	0.013262	1.993649	……
Image5	4.35398	1.348953	0.045323	2.271795	…..
. . . .					

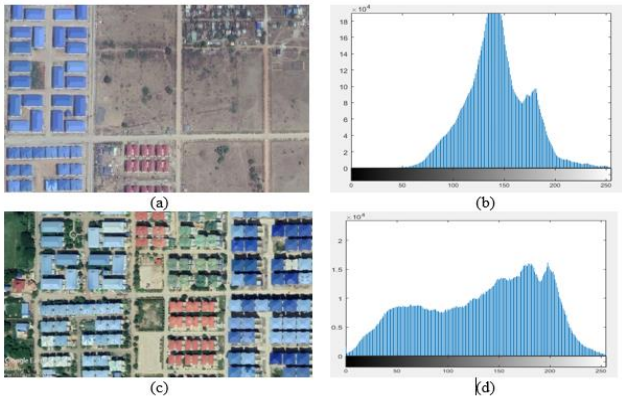

Figure 3. (a) ‘Chan Mya Thar Si’ township of (2015), (b) Histogram of ‘Chan Mya Thar Si’ township (2015), (c) ‘Chan Mya Thar Si’ township of (2020), (b) Histogram of ‘Chan Mya Thar Si’ township (2020)

Figure 2 shows the image histogram of ‘Chan Mya Thar Si’ township of Mandalay city, Myanmar. Image histogram is a type of histogram which is the graphical representation of the tonal distribution in digital image. In the visual analysis, histogram for a specific image a viewer will be able to detect the entire distribution properly.

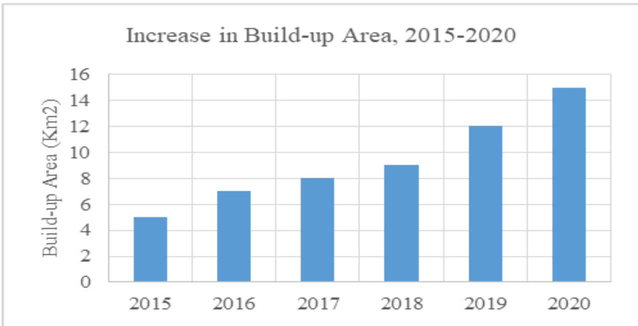

Figure 4. Temporal Changes in Build-up Area

Urbanization is associated with the urban plan, structure and morphology as a well as urban ecology that ultimately leads to some urban ecological and environmental problems of varying magnitude effective upon the ever increasing human population of the city. Figure 4 show the temporal changes in build-up area. It is revealed from the analysis made above the built up areas are increasing in a rapid pace.

The proposed method of image feature extraction based MRMR was most accurate in terms of built-up area extraction as compared to other classifiers, and hence was used for build-up area mapping for the years 2015 to 2020 which were then compared to determine the built up area expansion between 2015-2020 periods. Figure 5 shows the classification accuracy of build-up area expansion with support vector machine (SVM), K-nearest nighbor (KNN), Decision Tree (DT), Discriminate Analysis (DA), Naïve Bayes (NB) and Random forest (RF).

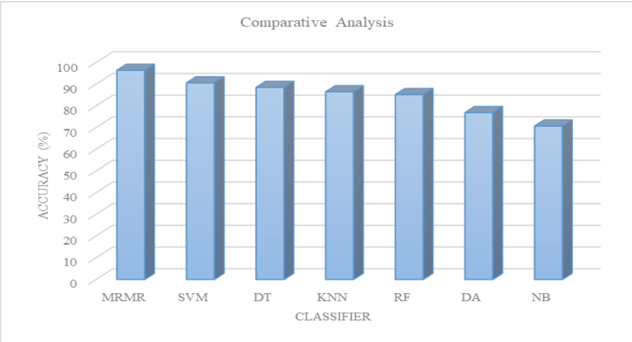

Figure 5. Comprative Analysis with Different Classfiers

In this study using MRMR, the relevance of fatures can be calculated by mutual information. If the expression of a histogram features has randomly or uniformly distributed in different images, its mutual information with these images is zero. If a histogram feature is strongly differentially expressed for different images, it should have large mutual information. Minimum redundancy maximum relevance (MRMR) approach is detecting the related features of image for urban built-up change area. Experiments essentially consist of performing image detection with MRMR and evaluating the results in terms of the respective probabilities of correct classification.

V. Conclusion

In this study, combination of image feature extraction with minimum redundancy maximum relevance, are proposed for automatically indicating the building change information from high resolution imagery. The experiments show that the proposed mutual information based MRMR are effective in integrating the gray level histogram features since they achieve higher correctness and lower errors than individual use of gray level histogram feature. It should be noted that the proposed feature extraction based MRMR are unsupervised building change detectors. A comparative study was conducted for comparison between the proposed method and several state-of-the-art image classification algorithms that had been proved to be effective in urban built up change detection system.

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Authors Profile

She received an M.Sc degree of physics in 2000. She got a doctor of philosophy in computer hardware technology in 2005. Her research interests is image processing and network security.

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