

Remote Sensing-Based Urban Land Use/Land Cover Change Detection and Monitoring

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Abstract

Recently, the pull of urban center is snowballing, more and more people move to the urban center to earn more money than rural areas especially in developing countries. Consequently, as more people arrive at urban areas, the more pressure will be on the urban environment. Population growth, immigration, and growing environmental problems entail advanced systems for city planners to help sustainable development in these rapidly changing regions. This problem can solve using remote sensing system. The purpose of this paper is to reveal the application of remote sensing technology for urban and use and land cover change detection and disclose certain sequences in detecting urban land use change.

Keywords: Remote sensing; Land cover change; Urban areas; Change detection

Introduction

Today, the pull of cities, clusters, and mega-cities is quiet growing. More and more people move to the urban centers of their country to participate in urban life, hoping to earn more money than in the countryside. In the developing countries urbanization is rapid for three reasons; population growth caused by natural increase, migration toward urban areas and the reclassification of rural areas as urban centers [1].

Swift population progression and urbanization are of countless anxiety to the sustainability of cities; thus, the more people on the earth, the greater the impact on the environment and pressures on the resources [1]. Population growth, regional in-migration, and increasing ecological problems require advanced methods for city planners, to support viable development in these quickly changing districts [2]. A better understanding of these impacts enhances estimating, modeling and forecasting ecosystem dynamics from local to regional levels [3]. Fast urbanization, especially the urban land expansion, and related problems like poverty, unemployment, poor sanitary condition and environmental degradation endure thought-provoking topics in most countries.

The rapid development of world-wide urbanization, and its related problems and the information the planners will need (extent and spatial distribution of various urban land uses, housing characteristics, population growth patterns and a concentration of resources at the expense of the surrounding countryside) cannot be analyzed without a systematic link between new technologies and in-situ observations [1]. Because of its merit especially wide area exposure, abundant data, multispectral resolution, remote sensing technology has been commonly applied to monitor and analysis land use dynamics and urban expansion. Remote sensing and GIS are very imperative kits to obtain precise and opportune information regarding the spatial dispersal of land use and land cover over huge areas.

Significance of Remote Sensing Technology for Urban Landscape

Since the start of the first Earth Resources Technology Satellite in 1972, there has been noteworthy bustle interconnected to mapping and monitoring environmental change resulted from man-made activities and natural events [4,5]

Urban remote sensing, particularly the application of space borne sensors is a newfangled issue for geographers. Before the introduction of space-borne platforms, the airborne platforms were leading as the principal source of data for remote sensing application. Nevertheless, recently the satellite-based sensors are contending. This advance is the effect of methodological enhancements that now permit satellite remote sensing systems to obtain imageries of high spatial resolution [1]. Aerial photography has very long archived data records, while satellite remote sensing for Earth observation started in 1972 with the first Landsat satellite. The most recent (since 1999) generation of remote sensing satellites affords very high-spatial-resolution data IKONOS (1 m) and Quick bird (0.61 m).

Satellite data are nowadays delightful to meet the mapping and monitoring which is important for of information for municipal planning. In particular, as the spatial resolution of remote sensing satellites advances, there is enhanced emphasis on applications for urban analysis. High-spatial resolution data succor in the examination of less 'planned' urban cores of older cities and the expanding 'edge cities' of developing nations [1,4,5].

Land use is a dynamic phenomenon that modifies through time and space due to human-made pressure and development. Appraising the present land use and its episodic change is convenient for urban planners, policy makers and natural resource managers and remote sensing offers an important Means of detecting and analyzing temporal changes [6]. The considerate of the progress dynamics of the urban cluster and land use changes is indispensable for ecologically achievable developmental planning. Thus, there is an obvious need for ceaseless monitoring of the phenomena of growth and mapping and scrutinizing LULC changes [4,5].

Defining the effects of land-use and land-cover change on the Earth system be contingent on a sympathetic of past land-use rehearses, contemporary land-use and land-cover patterns, and prognostications of forthcoming land use and cover, as pretentious by human distribution, economic development, technology and other factors [4,5,7,8]. Concerning urban the structure of and composition, it can be realized there are many objects that made up of small different material in the spatial arrangement that gives heterogeneous pixels in the earth observation satellite imageries. Furthermore, urban landscapes have 3D components. As one concerns factors affect urban remote sensing, it is necessary to examine geometric resolution (to separate objects spatially), spectral and radiometric resolution (to distinguish objects thematically) and temporal resolution (to get consistent image material on a separate date [1,9,10]

To analyze dynamic urban landscapes, tasks carry out at different levels. Tasks at the lowest level of information needs are on single blocks of buildings and require the largest scales (1:1000-1:5000) since individual houses, roads, etc., have to be detected in detail. The medium level would emphasis on a whole city and requires medium scales (1:10 000-1:25 000). The highest-level emphases on regions, agglomerations and their surrounding area and does not want a detailed differentiation inside the city, consequently, needing merely slight scales 1:50 000-1:100 000 [1].

Land-Cover and Land-Use Change Discovery Approach

Satellite imageries have been usually applied to examine the dynamic urban land use change analysis. Urban land use monitoring encompasses the use of multi-temporal images to detect the variation in land use due environmental situations and human activities amongst the acquisition dates of images [9].

Land use and land cover is a vigorous constituent in the interfaces of the human activities with the environment understanding. Land use can be defined as the human activities towards the land. Human uses of land for different activities such as for agriculture, urban development, logging, grazing and mining among many others [11]. Land use associated with human activity through an explicit portion of land [12]. While the land cover, is defined as the kind and state of vegetation such as forest, cropland, grass cover, wetland pastures, roads, and urban area [11].

Land use entails divers' land covers found on the earth's surface and abstract notions forming mixture socio-cultural aspects having slight physical important in reflectance properties and have limited relation in remote sensing. Remote sensing data record the spectral properties of surface materials, and hence, are further thoroughly related to land cover land use cannot be measured directly by remote sensing, but rather requires visual interpretation or sophisticated image processing and spatial pattern analyses to derive land use from total land-cover information and other supplementary data [4,5].

Image preprocessing

Image preprocessing is the most challenging in urban land cover change detection process and sometimes neglected. To identify land cover change with full confidence, accurately and precisely between consecutive years, the atmosphere disturbance should be modeled so that it will not affect the surface reflectance of land cover change detection process [13]. The accomplishment of land cover change detection analysis by using multi-dates remote sensing images depend up on the accurate radiometric and geometric correction. Multi-

temporal Landsat imageries geometric correction and radiometric correction are the most important [14,15].

Geometric correction: Geometric correction is the process of geo-referencing the satellite imageries to UTM map projection system to the zone of interest and ratifying by using an evenly distributed control points taken from digitized topographic map of corresponding areas and resampling to nearest neighborhood [14,16]. Geometric correction includes identifying the image coordinates similar with their true positions in ground coordinate and Re-sampling process is used to determine the digital values to place in the new pixel locations of the corrected output image. There are three common methods for re-sampling: nearest neighbor, bilinear interpolation, and cubic convolution [12].

Radiometric correction: Radiometric normalization of multi-dates imageries is acute stage in change detection analysis. High accuracy geometric registration of the multi-dates image data is a basic requirement for change detection. The reflectance values measured by the sensors are not the pure representation of the values reflected by earth surface features due to some external (sun angle, path radiance, and atmospheric condition) and in-sensor factors [9]. Consequently, this effect should be reduced because they make the task complicated [15,17]. Dealing with multi-date image datasets requires that images obtained by sensors at different times are comparable in terms of radiometric characteristics. Therefore, if any two or more datasets are to be used for quantitative analysis based on radiometric information, as in the case of multi-date analysis for detecting surface changes, they ought to be adjusted to compensate for radiometric divergence [15]. It is about correcting data irregularities occurred systematically or unsystematically by using algorithms. Generally, the objective of radiometric correction procedure is to convert satellite generated digital accounted to ground reflectance that is absolute surface reflectance [13].

Image enhancement: Image enhancement is the process applied to image data in order to more effectively display or record the data for subsequent visual interpretation. Normally, image enhancement contains many ways and methods applied for increasing the visual distinguishing among structures in a scene. The intention is to form or create new imageries from an original image to increase the visual interpretation of image [12] and to improve the visual interpretability of an image by increasing the apparent distinction between the features [18]. Three Broad approaches to enhancement includes manipulate the contrast of an image (level slicing and contrast stretching), spatial feature manipulation (spatial filtering, convolution, edge enhancement, and Fourier analysis) and multiple spectral bands of imagery (spectral rationing, principal and canonical components, vegetation components, and intensity-hue-saturation color space transformations). Choosing the appropriate enhancement for any particular application is the most challenging and an art and often a matter of personal preference [12].

Image classification process

Digital image classification in remote sensing contains grouping of pixels of an image to set of classes, such that pixels in the similar class are having like properties. The common type of image classification is based on the detection of the spectral response patterns of land cover classes. Remote sensing studies aiming on image classification has long attracted the devotion of the remote-sensing community as classification results are the basis for many environmental and socioeconomic applications. Scientists and practitioners have made

great efforts in developing advanced classification approaches and techniques for improving classification accuracy. However, classifying remotely sensed data into a thematic map remains a challenge, because many factors, such as the complexity of the landscape in a study area, selected remotely sensed data, and image-processing and classification approaches, may affect the success of a classification. Many factors, such as spatial resolution of the remotely sensed data, different sources of data, a classification system, and availability of classification software must be taken into account when selecting a classification method for use. Different classification methods have their own merits. The question of which classification approach is suitable for a specific study is not easy to answer. Different classification results may be obtained depending on the classifier chosen [19].

There are many different approaches to classifying remotely sensed data. However, supervised and unsupervised classifications are the most common classification approaches. Unsupervised change detection method is used less frequently in practice due to the difficulty in identifying and labeling change trajectories [20]. Regarding urban land use/cover classification, supervised classification method with maximum likelihood algorithm is one of the most popular widely used hard classifier by researchers [6,16,19]. The basic theory assumes Maximum-likelihood algorithm is that likelihoods are equal for all classes and that the input bands have normal distributions. supervised classification involves the classification of pixels of unknown identity by means of a classification algorithm using the spectral characteristics of pixels of known informational class (referred to as training areas) identified by the expert.

This classification system helps the expert to full control of the informational categories, or classes, to be assigned in the final classification. This allows for easier comparison with other classifications by using identical classes. The analyst does not face the problem of matching spectral classes to informational classes, because this is addressed during the selection of training areas and, the training data can be compared with the final classification as one means of detecting serious errors in the classification process. Supervised classification is controlled by users' knowledge and, is constrained and may even be biased by their subjective view. The classification can, therefore, be misguided by inaccurate training area information and/or incomplete user knowledge. Realizing the limitations of both major classification methods is recommended [21].

Classification accuracy assessment

Accuracy assessment is very important for understanding the developed results and employing these results for decision-making [20]. Classification accuracy assessment is very important in land use mapping and to understand map quality and reliability [4,5]. Ultimately there is no satisfactory method to assess the absolute accuracy of image classification for remote sensing Earth observation applications. Even an assessment or an estimate of the relative accuracy of classification does, however, provide valuable knowledge for us to accept or reject a classification result at a certain confidence level [5].

Error matrix is very important and commonly used tools to assess accuracy of particular map. It compares and matches pixel in the classified images with that of ground data. The general accuracy of the classified image compares how each of the pixels is classified versus the actual land cover conditions obtained from their corresponding ground truth data. Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. Accuracy measures errors of commission, which

characterizes the probability of a classified pixel to corresponding the land cover type of its corresponding real-world location. The error matrix summarizes results by comparing a primary reference class label to the map land-cover or land-use class for the sampling unit and presents errors of inclusion (commission errors) and errors of exclusion (omission errors) in a classification. The Kappa statistic is a discrete multivariate technique used in accuracy assessment. A standard overall accuracy for land-cover and land-use maps is at least 85 percent [22] and 90%. However, no such standard accuracy exists for change-detection scenarios, although 80–85% appears to be a reasonable limit depending on complexity of the mapping study [5].

Class smoothing process

The classification procedure usually leaves use with a small number of isolated, generally poorly classified or unclassified, pixels that are often located at the boundaries between two clearly assigned areas. They give the picture a 'pointillist' look that may be problematic for producing maps. In such a case, homogenizing the classification by reassigning the pixels to one or the other class is desirable [23]. Post-classification smoothing with a majority filter is essential to reduce unnecessary detail and further improve the classification accuracy. Filtering comprises conveying isolated pixel to the leading class within which it lies.

The classified images usually manifest a salt-and-pepper appearance due to the inherent spectral inconsistency faced by a classifier when applied on a pixel-by-pixel basis. For example, in an agricultural area, several pixels scattered throughout a corn field may be classified as soybeans, or vice versa. In such situations, it is often desirable to "smooth" the classified output to show only the dominant classification [12].

A classification image often contains noise caused by the isolated pixels of some classes, within another dominant class, which can form sizeable patches. It is reasonable to presume that these isolated pixels are more likely to belong to this dominant class rather than to the classes that they are initially assigned to; these probably arise from classification errors. An appropriate smoothing process applied to a classification image will not only 'clean up' the image, make it visually less noisy, but also improve the accuracy of classification [23].

LULC Change Detection

The basic premise in using remotely sensed data for change detection is that changes in the objects of interest will result in changes in reflectance values or local textures that are distinguishable from changes which caused by atmospheric conditions, illumination and viewing angles. Because digital change detection is affected by spatial, spectral, thematic and temporal constraints, and since several change detection methods are possible to use, the choice of appropriate algorithm for a given research project is important [24,25]

Change detection process is to recognize LULC on digital images that change features of interest between two or more dates. Change detection encompasses the application of multi-date or multi-temporal data sets to differentiate areas of land cover change between dates of imaging. Ideally, change detection procedures should involve data acquired by the same sensor and be recorded using the same spatial resolution, viewing geometry, spectral bands, radiometric resolution, and time of day. Accurate spatial registration of the various dates of imagery is also a requirement for effective change detection [12,26].

There are various change detection techniques used to examine the variation in LULC change by using remotely sensed images. From these techniques, pre- and post-classification comparisons have been widely used. In the pre-classification approach (sometimes called simultaneous analysis), procedures such as image differencing, band rationing, change vector analysis, direct multi-date classification, and vegetation index differencing and principle component analysis have been developed. However, while these techniques are effective for locating change, they cannot identify the nature of change [27].

On the other hand, post-classification comparisons examine changes over time between independently classified land cover data. Notwithstanding its difficulties associated with post-classification comparisons [9], this technique is the most widely used for identifying LULC changes, particularly in urban environments. However, one of the disadvantages associated with this approach is that the accuracy of the resultant LULC change maps depends on the accuracy of the individual classification, meaning that such techniques are subject to error propagation [28]. Nonetheless, such post-classification methods are predominantly advantageous for generating 'from-to' maps which can be used to elucidate the extent, location, and nature of the changes shown. In addition, the technique can be employed using data acquired from sensors with different spatial, temporal and spectral resolutions [27].

Various researches have shown that post-classification comparison was found to be the furthestmost perfect process and presented the advantage of demonstrating the nature of the changes [29]. Post-classification change detection technique is efficient in detecting the nature, rate, and location of changes, and has been successfully used by a number of researchers in the urban environment [27]. This method compares classification a posteriori, as the available data for the study acquired in different seasons by a different sensor with different spatial resolutions and, it is a more common procedure for comparing land use/cover dynamics.

Change detection can be defined as the process of identifying differences in the state of an object or phenomenon by observing it at different times. This process is usually applied to Earth surface changes at two or more times. Understanding relationships and interactions to better manage and use resources. Change detection is useful in many applications such as land use changes, habitat fragmentation, and rate of deforestation, coastal change, urban sprawl, and other cumulative changes [5].

The direct multi-date classification is based on the single analysis of a combined dataset of two or more different dates, in order to identify areas of changes. The post-classification comparison is a comparative analysis of images obtained at different moments after previous independent classification. The most obvious method of change detection is a comparative analysis of spectral classifications for times t_1 and t_2 produced independently [9]. In this context, it should be noticed that the change map of two images will only be generally as accurate as the product of the accuracies of each individual classification. The accuracy of relevant class changes depends on spectral separability of classes involved.

Precise geometrical registration and atmospheric correction or normalization between multi-temporal images is prerequisites for a change detection project. The crucial factors for successfully implementing change detection are selecting suitable image acquisition dates and sensor data, determining the change categories, and using appropriate change detection algorithms. Identifying a suitable change

detection technique has considerable significance for a study area to produce good change detection results [24]. There are several change detection techniques with their advantages and disadvantages. In general, change detection techniques can be grouped into two types: the first is detecting binary change/non-change information, for example, using image differencing, image rationing, vegetation index differencing and PCA; and second one is detecting detailed 'from-to' change, for example, using post-classification comparison, CVA (change vector analysis) and hybrid change detection methods. One critical step in using the methods for change/non-change detection is to select appropriate threshold values in the tails of the histogram representing change information [20]. In detailed 'from-to' change detection, the key is to create accurate thematic classification images. The errors of each date of thematic images will affect the final change detection accuracy. In practice, an analyst frequently selects several methods to implement change detection in an area of interest, then compare and identify the best results through accuracy assessment.

There is no single method is suitable for all cases each detection method depends on an expert's knowledge of the change detection methods and the skill in handling remote sensing data, the image data used, and characteristics of the study area. Because of the difficulty in identifying a suitable method, in practice, different change detection techniques are often tested and compared to provide the best result based on the accuracy assessment or qualitative assessment. The most common change detection methods are image differencing, PCA, CVA and post-classification comparison [20].

Output and its Application

Local, regional as well urban planners require current information to manage urban development and plan for future urban change. In peri-urban areas, land cover change is very dynamic and rapid. Then, the dynamic land cover change particularly peri-urban areas are further complicated to obtain up-to-date information regarding newly constructed houses, newly established industries, and commercial developments. Therefore, the accurate urban land cover change detection is very significant to formulate strategies that reduce poverty and environmental effects and promote the sustainable development of urban areas [4,5,30,31].

Urban planners in big cities are engaged a large amount of effort, times well as the resource to update land cover/use information to get current information. An integrate approach to land use land cover change detection is best to provide land use information for planners. Whereas remote sensing data is the mean of providing the change in land cover conversion reference to existing land use and land cover changes. Through the integration of varied datasets, the land-use planner is able to make responsible decisions based on existing information within the digital database, as well as create new information through various spatial analysis techniques [4,5,21].

Both Remote sensing (RS) data and Geographical information system (GIS) can deliver good opportunities for integrated analysis of spatial data and product development. The interactions of remote sensing and geographical information system can be described as follows;

Remote sensing data can be used as input data or major data sources for analysis within a Geographic information system.

Geographical information system data can provide additional data improve remote sensing data analysis for distinguishing between land-cover and land-use classes [5].

Remote sensing and geographic information system in combined applied to change detection analysis and modeling urban growth.

Additionally, remote sensing output has often been used to help in the formulation of policies and provide insight into land-cover and land-use patterns, and multi-temporal trends. There has been an evolution in the manner in which remote sensing, associated technologies, and analysis techniques are being used to map land cover and land-use change at local, landscape, regional and continental scales. Today, remote sensing imagery from satellite and airborne platforms provide digital data at scales of observation that meet various mapping criteria for characterizing anthropogenic and natural surfaces [4,5].

In particular, Remote Sensing based multi-temporal land use change data provide information that can be used for assessing the structural variation of LULC patterns, which can be applied to avoiding irreversible and cumulative effects of urban growth and are important to optimize the allocation of urban services. In addition, accurate and comprehensive land use change statistics are useful for devising sustainable urban and environmental planning strategies [3]. It is therefore very important to estimate the rate, pattern, and type of LULC changes in order to predict future changes in urban development [27].

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