UNIVERSITI PUTRA MALAYSIA

USE OF HYBRID CLASSIFICATION ALGORITHM FOR LAND USE AND LAND COVER ANALYSIS IN DATA SCARCE ENVIRONMENT

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By

JWAN M. MOHAMMED AL-DOSKI

Thesis Submitted to the School Graduate Studies, Universiti Putra Malaysia, in Fulfillments of the Requirements for the Degree of Master of Science.

September 2013

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DEDICATION

بسم الله الرَّحْمَنِ الرَّحِيمِ

وَيَرَى الَّذِينَ أُوتُوا الْعِلْمَ الَّذِي أُنزِلَ إِلَيْكَ مِن رَّبِّكَ هُوَ الْحَقَّ وَيَهْدِي إِلَى صِرَاطِ الْعَزِيزِ الْحَمِيدِ

سورة سبأ الاية ٦

صدق اللهُ العظيم

To who survived the Anfal killing grounds and to all those who did not
To all victims of Iraq's chemical warfare in Halabja
To those who are fighting against tyranny and oppression
For those who love knowledge and are pursuing it for a better world
To my ever-loving parents
To my dearest siblings
To my lovely sister, Jivan Al-doski

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

USE OF HYBRID CLASSIFICATION ALGORITHM FOR LAND USE AND LAND COVER ANALYSIS IN DATA SCARCE ENVIRONMENT

By

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September 2013

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The technique of remote sensing satellite imaging has played a significant role in facilitating the study of land use/land cover changes (LULC). This is because the information that can be extracted from images constitutes a fundamental key in many diverse applications such as Environment, Planning and Monitoring programs and others. LULC changes are mainly the result of human intervention and natural phenomena such as population growth, urbanization, wars and other factors. During the 1980-1988 Iraq-Iran war, many cities and villages in the north of Iraq were shelled several times with chemical weapons that caused many changes in land covers. Among the cities seriously affected by these chemical weapons is Halabja City (the study area for this research), which was shelled on 16 March 1988, leaving approximately 5,000 people dead and 7,000 injured with long-term damage to their health. In this study, vegetation indices, tasseled cap transformation, hybrid

classification as a combination of k-means and support vector machine algorithms, and post-classification comparison were respectively implemented to detect and assess LULC in Halabja. Two Landsat 5 (Thematic Mapper - TM) images obtained in 1986, 1990 with one Landsat 7 (Enhanced Thematic Mapper Plus - ETM+) image acquired in 2000 were used. All images were geometrically corrected and projected to UTM, Datum WGS_84 and Zone 38N using automatic image to image registration with polynomial transformation equations and a nearest neighbor re-sampling algorithm. The root mean square (RMS) error was less than 0.5 pixels. Subsequently, all images were atmospherically corrected by applying dark object subtraction and sub-setted to (1400) samples, (999) lines. The hybrid classifier with the aid of visual interpretation tools, knowledge-based assignment and other supplementary data like Google earth images and vegetation indices were run on subsets to classify images into five thematic classes based on the NLCD 92 classification system scheme (Water Bodies; Shrub Land; Cultivated/Planted Area; Low-Intensity Urban Area; and Bare Land). To assess classification accuracy, the classified images were randomly sampled to produce confusion matrix which provided LULCC maps with an average overall accuracy of 95% and 0.94 Kappa statistic that tendered them deal for further qualitative and quantitative analysis of land cover changes through a post-classification. Based on the overall accuracy and kappa statistics, hybrid classifier was found to be more preferred classification approach than k-means and SVM.

A multi-date post-classification comparison algorithm was used to determine LULC changes in two intervals, 1986-1990, and 1990-2000. Change analysis during 1986 to 1990 revealed that all classes decreased and showed few changes except the bare land which showed an increase of about 30%. The Low intensity urban changed area

was determined and overlaid with chemical weapons bombing location GPS points; roads with the aid of the NDBI index to locate low intensity urban areas changes. It was noticed that bombed places are the same places where the urban area changed. During the 1990 to 2000 period, there were significant increases in low intensity residential and cultivated / plant areas. The low intensity residential area increased by 12 km^2 (61%). This increment comes from conversion of 2% cultivated/planted area, 2% of bare land and 8% of water bodies while cultivated / plant areas increased by 83%. Most of the increments of this class come from the conversion of 36 % water bodies, 24 % of shrub land, 14 % of bare land, and 6% of low intensity residential areas. On the contrary, there was a significant decrease in water bodies by 55% overall and other class designations. In conclusion, hybrid classification as a combination of k-means and support vector machine algorithms and post-classification comparison change detection technique can be used to monitor land cover changes in Halabja city, Iraq.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGGUNAAN ALGORITMA PENGELASAN HIBRID BAGI ANALISIS PENGGUNAAN DAN LITUPAN TANAH DALAM DATA PERSEKITARAN ALAM BERKURANGAN

Oleh

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Teknik pengindera jauh pengimejan satelit telah memainkan peranan yang sangat penting dalam menjalankan kajian berkenaan dengan penggunaan tanah/perubahan litupan tanah (LULC). Ini adalah kerana maklumat yang diperolehi daripada imej-imej menampilkan pentunjuk penting dalam pelbagai aplikasi seperti Alam Sekitar, Program-program Perancangan dan Pemantauan dan sebagainya. Perubahan LULC sebahagian besarnya adalah hasil daripada campur tangan manusia dan fenomena semulajadi seperti peningkatan populasi, urbanisasi, peperangan dan faktor-faktor lain. .Semasa peperangan Iraq-Iran pada 1980-1988, banyak bandar dan kampung-kampung di Utara Iraq telah dihujani beberapa kali dengan senjata kimia yang menyebabkan banyak perubahan ke atas litupan tanah. Antara bandar yang terkesan secara serius dengan senjata kimia ini adalah Bandar Halabja (kawasan penyelidikan

bagi kajian ini), yang mana telah dibom pada 16 Mac 1988, menyebablcan lebih kurang 5,000 orang meninggal dunia dan 7,000 cedera dengan kesan jangka panjang kepada kesihatan mereka. Dalam kajian ini, indeks tumbuhan, Transformasi Tasseled Cap klasifikasi hyibrid seperti kombinasi min-k dan algoritma mesin vector sokongan dan perbandingan pasca-klasifikasi masing-masing telah diimplementasikan untuk mengesan dan menilai LULC di Halabja. Imej-imej daripada dua Landsat 5 (Pemeta Tematik - TM) diperolehi pada 1986, 1990 dengan imej daripada satu Langsat 7(Pemeta Tematik Tertonjol Tambahan - ETM+) diperolehi dalam tahun 2000 telah digunakan. Kesemua imej telah diperbetulkan secara geometric dan dipancarkan kepada UTM, Datum WGS_84 dan Zone 38N menggunakan imej automatik kepada pendaftaran imej dengan persamaan transformasi polinomial dan algoritma persampelan semula terdekat. Ralat punca min kuasa dua (RMS) adalah kurang daripada 0.5 piksel. Kemudian, kesemua imej telah diperbetulkan secara atmosfera dengan mengenakan pengurangan objek legam dan sub-setkan kepada sampel (1400) garisan (999). Pengelas hibrid dengan bantuan daripada peralatan interpretasi visual, tugasan berdasarkan maklumat dan data tambahan lain seperti imej Google Earth dan indeks vegetasi telah dijalankan keatas subset untuk mengelaskan imej kepada lima kelas tematik berdasarkan kepada sistem skema klasifikasi NLCD 92 (Kandungan Air; Tanah Renek; Kawasan Tanaman; Kawasan Bandar Keamatan Rendah; dan Tanah Kosong). Untuk menilai ketepatan pengelasan, imej terkelas telah disampelkan secara rawak untuk menghasilkan matrik kekalutan yang menyediakan peta LULCC dengan purata keseluruhan ketepatan adalah 95% dan statistik 0.94 Kappa yang menggantikan mereka untuk analisis kualitatif dan kuantitatif lebih lanjut ke atas perubahan litupan tanah menerusi pasca pengelasan. Berdasarkan kepada ketepatan keseluruhan dan statistik kappa, pengelas

hybrid telah dijumpai sebagai pendekatan pengelasan yang lebih diminati berbanding min k dan SVM.

Algoritma perbandingan pasca pengelasan pelbagai tarikh telah digunakan untuk menentukan perubhan LULC dalam dua selang masa 1986-1990, dan 1990-2000. Analisis perubahan semasa 1986 sehingga 1990 menunjukkan bahawa kesemua kelas berkurangan dan menunjukkan beberapa perubahan kecuali tanah kosong yang mana telah menunjukkan peningkatan sebanyak 30%. Kawasan perubahan bandar berkeamatan rendah telah dikenalpasti dan dilipat tindih dengan lokasi poin GPS pengeboman senjata kimia; jalanraya dengan bantuan indeks NDBI untuk menentukan perubahan kepada kawasan Bandar yang berkepadatan rendah. Ianya didapati bahawa tempat yang dibomkan adalah sama dimana kawasan perubahan di bandar. Semasa jangkamasa 1990 hingga ke 2000, terdapat penambahan yang signifikan dalam kawasan berkepadatan rendah dan kawasan tanaman/tumbuhan. Kawasan perumahan berkepadatan rendah.telah meningkat sebanyak 12 km^2 (61%). Peningkatan ini datangnya daripada penukaran bagi 2% kawasan tanaman/tumbuhan, 2% tanah lapang dan 8% bagi kandungan air sementara kawasan tanaman/tumbuhan telah meningkat sebanyak 83%. Kebanyakan daripada penambahan bagi kelas ini datangnya daripada penukaran bagi 36 % kandungan air, 24 % bagi kawasan tanaman reneh, 14 % bagi tanah lapang, dan 6% bagi kawasan perumahan kepadatan rendah. Sebaliknya terdapat pengurangan yang signifikan bagi kandungan air bagi keseluruhan 55% dan designasi kelas yang lain. Sebagai kesimpulannya, pengelasan hybrid adalah satu kombinasi bagi min K dan algoritma vector mesin sokongan dan teknik perbandingan pasca pengelasan pengesanan perubahan boleh digunakan untuk memantau perubahan bagi litupan tanah di Bandar Halabja, Iraq.

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APPROVAL

I certify that an Examination Committee met on September 20, 2013 to conduct the final examination of Jwan M Mohammed Al-doski on her thesis entitled "USE OF HYBRID CLASSIFICATION ALGORITHM FOR LAND USE AND LAND COVER ANALYSIS IN A DATA SCARCE ENVIRONMENT" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.
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DECLARATION

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Signature		Signature	
Name of Chairman of Supervisory Committee:	**Shattri B Mansor, PhD**	Name of Member of Supervisory Committee:	**Helmi Zulhaidi Bin Mohd Shafri, PhD**

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LIST OF ABBREVIATIONS

RS	Remote Sensing
NASA	National Aeronautics and Space Administration
ETM+	Enhanced Thematic Mapper Plus
LULC	Land Use / Land Cover
FCC	False Color Composite
GCP	Ground Control Point
TM	Thematic Mapper
UTM	Universal Transverse Mercator
VNIR	Visible and Near Infra-Red
WGS 84	World Geodetic System 1984
VI	Vegetation Index
NDVI	Normalized Difference Vegetation Index
NDBI	Normalized Difference Built Index
RMSE	Root Mean Square Error
SWIR	Short Wave Infrared

CHAPTER 1

INTRODUCTION

1.1 Introduction

During the period 1946 to 2001, there were 225 armed conflicts globally and 34 of them were active in all of or part of 2001 (Gleditsch et al., 2002), accounting for approximately 20 million human casualties (Fearon & Laitin, 2003). In 2010 alone, there were 30 active armed conflicts in 25 locations around the world (Themner & Wallensteen, 2011). While the number of conflicts increased significantly during the second half of the 20th century, their primary causes remain largely unchanged; that is, differential access to critical resources and disagreements about ideology and/or the nature of collective identity (Pedersen, 2002). On the other hand, the prevailing type of war in modern times tends to occur within states, rather than between states (Fearon & Laitin, 2003; Pedersen, 2002).

During the last thirty years of the 20th century, Iraq in particular has been deeply and disproportionately affected by several conflicts, including the Iran-Iraq War; to the Gulf War and the initial campaign of Operation Iraqi Freedom (OIF); to economic warfare in the form of comprehensive United Nations (UN) sanctions; to the long-term occupation and reconstruction of OIF, post invasion (Gibson & Campbell, 2011). Although these conflicts were almost continuous, with little time separating episodes which sometimes merged with one another, the styles of warfare were distinct. These wars mainly break out from the high levels of poverty, heavy economic dependence on resource-based primary exports, control of the natural resources in Iraq such as oil and failed political institutions.

The drastic and widespread damage that prolonged warfare has brought about and affected society, the economy, private and public property, and the infrastructure can be seen and felt everywhere in Iraq. No one has been spared by the conflict and everyone has suffered, in one way or another. These wars are considered devastating, partly as a result of the associated high levels of civilians killed, refugees and displaced people, which continued the cycle of poverty and has disastrous implications on human health (Maguen, 2010; Marmar, 2009; Sidel & Levy 2008; Farhood, 1993).

By the end of the wars, there were about 1.6 to 2 million people who were counted as refugees or internally displaced people both permanently and temporarily, within the Iraq or abroad as a result of war or internal crisis. However, there are no conclusive figures for the number of people killed but the United States occupation in 2003 in an estimated survey has claimed that during the Iran-Iraq War from September 1980 to August 1988, between 150,000 and 340,000 were killed (see figure 1.1) and about 250,000 wounded, while more than 50,000 were being held as prisoners of war in Iran whereas, during the Gulf War, the total combined figure for Iraqis and dissidents killed could be as high as 300,000 and approximately 500,000 children died because of international trade sanctions (Bruce Harris, 2008 ;BBC., 1988a; BBC., 1988b; Steven Johns.,2006). During the most recent war, the long-term occupation and reconstruction of Operation Iraqi Freedom (OIF), from March 2003 to December 2011, there are no estimates on the number of lives lost (Human Rights, 1993).

Figure 1.1 Dead Bodies of Halabja Residents Unloaded for Mass Burial
(Source: Black, 1993).

The armed conflicts in Iraq were indirectly responsible for the destruction and degradation of the environment and it contributed in turn to further conflict (UNEP, 2003a; Barnaby, 1991). Generally, the environmental impacts of war can be understood by examining the magnitude and duration of effects, involved ecosystems in specified geographic locations, the use of individual weapons systems, the results of particular production processes and the cumulative combined effects of specified military campaigns. From this perspective, four activities can be seen as having prolonged and pervasive environmental impact with significant consequences for human populations, production and testing of nuclear weapons, aerial and naval bombardment of terrain, dispersal and persistence of land mines and buried ordnance, and use or storage of military despoliants toxins and waste (Leaning, 2000 ; Abuelgasim & Woodcock, 1999; Bagour, 2006;. Barnaby, 1991; El-Baz, 1994; Stephens, & Matson, 1993)

There was a great damage to an estimated 4,000 cities, villages and towns and their surrounding environments and economic losses in financial terms have been estimated to be billions of dollars (Baker, 2007). The sequence of aerial bombardment, destruction of homes and urban and rural infrastructure, forests, farms, transport systems and irrigation networks and progressive waves of dislocated or homeless people, can be seen in all parts of Iraq. For example, in the 30 years of the war in Iraq, an era marked by sieges of cities, attacks on safe havens and the pulverization of towns to effect ethnic cleansing, millions of people have been forced to flee within or across national borders. These wars crippled the urban support systems of major cities and led to water pollution, decline of safe drinking water and the significant spread disease, especially bacterial disease such as typhoid fever that have increased tenfold since 1991. Additionally, the bombardment of sulfur plants and oil fields that burned for a whole month in July 1991 were a vivid image of a major part of the environmental damage caused by the war that has been contributing to air pollution(see figure 1.2).

Figure 1.2 Oil Field Fire during the Gulf War
Source: http://www.geotimes.org/may03/geophen.html

Recently, sandstorms and the sand drift were some of the war effects noted during and after the first Gulf war in Iraq which resulted from movements of military vehicles across the landscape that caused several environmental and health problems. In recent years, scholars have begun paying closer attention to the negative impacts of armed on the environment. Recently, Reuveny et al. (2010) examined the impact of war on several environmental indicators such as CO^2 and NO emissions, deforestation and a composite environmental stress indicator with mixed results, including the finding that warfare increases deforestation in a country when fought at home, and promotes forest growth when fought abroad, particularly among Least Developed Countries (LDCs). Hanson et al. (2009) similarly looked at the occurrence of war and its relationship to areas of high biodiversity globally and found that over 90% of the major armed conflicts between 1950 and 2000 occurred within countries containing biodiversity hotspots and more than 80% actually occurred within a hotspot.

However, the devastation of the Iraqi wars is usually assessed based on the number of people who have been killed, missing people and short term problems. Very few studies have used satellite products to gain insight into the causes and consequences of armed conflict in Iraq. The research conducted as part of this dissertation seeks to examine the impacts of conflict on land cover and land use in Halabja city in northern Iraq using satellite remote sensing data (See figure 1.3) was specifically chosen as the area of study for this research because of its high biodiversity and unique geographical position, where the cessation of hostilities in 1992 has made it possible to examine the effects of war on the landscape.

Figure 1.3 Gases Rising over Halabja City, 1988
(Source: Salih, 1995).

1.2 Problem Statement and Motivation

In addition to the massive numbers of dead and missing people during the three decades of wars and conflicts, international sanctions have affected several domains in the north of Iraq (Kurdistan Region), among them: the agricultural production, government policies, marketing and industry. As a result there is a substantial change in the land cover especially since 1992 when the Kurdish Regional Government (KRG) started rebuilding cities and improving living conditions to better standards. So the KRG established many governmental bodies and agencies, and used urban planners and decision makers. Among these were the environmentalists who expressed much concern about the detection and the quantification of surface changes that occurred during the war and reconstruction stages. They called for the clarification of changes and understanding the relationship between war and natural phenomenon as well as better management and usage of the resources. Among the different cities of Iraq, which were greatly affected by the war is Halabja city; it took the heaviest hit because it was attacked both physically and environmentally (by the chemical weapons that were used). Lately, the KRG has put great effort and attention to rebuild the city. According to some reports, the Kurdistan Region has shown changes: there are 35 new villages that have been provided with electricity and 700 other villages have been repaired, around 1000 km of new roads/highways have been built, 600 km repaired and resurfaced, 15 new bridges constructed with around 26% of Kurdistan's budget spent on construction and reconstruction (Kurdistan & Hayastan, 2007).

So far, to the knowledge of the researcher, no study has been done on Iraq using remote sensing technology to investigate the land use / land cover changes of chemical weapons in Kurdistan region, Iraq.

1.3 Research Objectives

The main goal of this research is to detect land use / land cover changes as a result of war's impact in the short-term 4 years (pro and after shelling with chemical weapons) as well as a longer term of 10 years in Halabja city, Iraq. To achieve this, the following sub-objectives can be adding as follows:

1. Identification of land use/land cover changes using vegetation indices and hybrid classification change detection algorithms.
2. Produce land use/land cover classification maps accurately on a regional scale of Halabja city.
3. Produce land use land cover changes maps for the study area within the periods of 1986 to 1990 and 1990 to 2000.
4. Examine both qualitative and quantitative changes using advance post-classification comparison technique.

1.4 Research Questions

In order to fulfill the above-mentioned objectives, the following research questions are asked:

1. Can the land use/land cover changes in the study area identify the chemical weapons effects using optical satellite data such as Landsat?
2. How effective is the hybrid classification technique for image classification in the context of the study area?
3. What are the land use/land cover changes in the study area in two the time periods due to chemical weapons effects?
4. How can post-classification be used to strengthen the justification of accuracy for the hybrid classification?

1.5 Scope and Limitations of Research

The present research has limitations and difficulties. First of all, considering the technical aspects, the satellite images used are restricted to certain spatial, temporal, and spectral resolution. Furthermore, the resolution has a great impact on the effectiveness of the change detection techniques. Secondly, the date of chemical bombardment has a significant effect on the availability of satellite imagery as well as the type of satellite sensor. Moreover, data types have effects on the number of methodologies employed in this study. Thirdly, lack of high quality reference and ground truth data affects the evaluation of classification and accuracy assessment.

1.6 Thesis Outline

Chapter One of this thesis deals with the general introduction, which includes the background of the Iraq War and attack on Halabja, the problem statement and motivation, objective and limitations of the study. Chapter Two is the overview of the study which gives a brief introduction about the role of remote sensing in land use/land cover, change detection with general types and applications of change detection techniques with brief background information about Iraq and Halabja city attack and chemical weapons, and a brief literature review on change detection techniques together with a discussion of the considerations before implementing change detection and related works. Chapter Three deals briefly with the description about study area, and data resolution consideration for land cover changes with a description of the data used and their sources as well as, deals extensively with the methodology employed: pre-processing, hybrid classification and description about classification algorithms used and post-classification of change detection techniques on data. Chapter Four focuses on the results and analysis. Finally, Chapter Five concludes with a summary and recommendations for further study.

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