Faculty of Information and Communication Technology

COMPARATIVE ANALYSIS ON MULTISPECTRAL IMAGES BASED ON FUZZY APPROACH

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Master of Science in Information and Communication Technology

2020

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Information and Communication Technology

Faculty of Information and Communication Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2020

DECLARATION

I declare that this thesis entitled "Comparative Analysis on Multispectral Images based on Fuzzy Approach" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Afirah Binti Taufik

Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature	:	
Supervisor Name	:	Profesor Madya Dr. Sharifah Sakinah Binti Syed Ahmad
Date	:	

DEDICATION

I dedicate this work to my family.

My husband

Mohammad Farkhan Mohd Tahrim

My daughter

Aleesya Mohammad Farkhan

My parents

Nilawati Hamzah

Taufik Pandak Hassan

and to all my siblings, family and friends.

I dedicate my love to you all always in this world and the Hereafter.

Thank you Allah.

ABSTRACT

In particular, the vital information for classification can get lost due to a vast amount of data flow in the classification of remotely-sensed images. Nonetheless, existing techniques used for classifying mixed pixels in remotely-sensed imagery are not too efficient due to the homogenous category. In this study, the information of multispectral data of Landsat 8 is extracted to the three indices are used in this study are to represent of three categories; vegetation, non-vegetation and water body, are normalized difference vegetation indices (NDVI), normalized difference built-up indices (NDBI), and normalized difference water indices (NDWI). The indices are described as the input data for the methods of classification. In the present study, the fuzzy approach methods are developed and tested for a classification land cover mapping. An investigation is conducted based on a comparative study between fuzzy c-means, fuzzy supervised (adaptive neuro-fuzzy inference system) and other unsupervised methods, such as k-means. The evaluation of classification approaches on the ability to classify land cover classes with per-pixel digital image classification techniques is based on the user, producer and overall accuracy and kappa coefficient. For imbalance image datasets, the Klang and Krai image are compared to observe the distribution of data affect into user's accuracy (UA) and producer's accuracy (PA). For Klang data, the results show that the method of FCM performs better for UA in the non-vegetation class and PA in the vegetation class, with a percentage of 95.2% and 98.7% respectively. For Krai data, the method of FCM performs better for UA in the vegetation class and PA in the water class with a percentage of 98% and 99% respectively. In future work, more indices and category of classes can be considered to deal with the multispectral data for Landsat 8.

ABSTRAK

Dalam proses klasifikasi, maklumat penting mudah tercicir disebabkan oleh banyaknya aliran data dalam pengklasifikasian imej penderiaan jauh. Walau bagaimanapun, teknik sedia ada yang digunakan untuk mengklasifikasikan piksel campuran dalam imejan yang dikesan jauh tidak terlalu cekap kerana merupakan kategori homogen. Dalam kajian ini, maklumat data multispektral Landsat 8 diekstrak ke tiga indeks yang digunakan dalam kajian ini adalah untuk mewakili tiga kategori; tumbuh-tumbuhan, bukan tumbuh-tumbuhan dan badan air, adalah indeks indeks tumbuhan yang berbeza (NDVI), indeks binaan perbezaan (NDBI), dan indeks air perbezaan (NDWI). Indeks digambarkan sebagai data masukan untuk kaedah klasifikasi. Dalam kajian ini, kaedah pendekatan kabur dibangunkan dan diuji untuk pemetaan sampingan tanah pengelasan. Penyiasatan dilakukan berdasarkan kajian perbandingan antara fuzzy c-means, fuzzy supervised (sistem inferensi neuro-fuzzy adaptif) dan kaedah lain seperti k-means. Penilaian pendekatan klasifikasi mengenai keupayaan untuk mengklasifikasikan kelas perlindungan tanah dengan teknik pengklasifikasian imej digital setiap-pixel didasarkan pada pengguna, pengeluar dan ketepatan keseluruhan dan pekali kappa. Untuk dataset imej yang tidak seimbang, imej Klang dan Krai dibandingkan dengan memerhatikan pengagihan data mempengaruhi ketepatan pengguna (UA) dan ketepatan pengeluar (PA). Bagi data Klang, keputusan menunjukkan bahawa kaedah FCM adalah lebih baik untuk UA di kelas bukan tumbuhan dan untuk PA dalam kelas tumbuhan, dengan peratusan masing-masing 95.2% dan 98.7%. Untuk data Krai, kaedah FCM adalah lebih baik untuk UA di kelas tumbuhan dan PA dalam kelas air dengan peratusan 98% dan 99% masing-masing. Pada masa akan datang, lebih banyak indeks dan kategori kelas boleh dipertimbangkan untuk menangani data multispektral untuk Landsat 8.

ACKNOWLEDGEMENTS

Alhamdulillah, I am thankful to almighty Allah Subhanahuwataala, the Most Gracious and the Most Merciful. His infinite mercy has guided me to complete this MSc. work. May peace and blessing of Allah be upon His Prophet Muhammad Sallallahualaihiwassalam. Who has been sent by Him as a mercy and blessing for the entire universe. I express my sincere gratitude to Associate Professor Dr. Sharifah Sakinah Binti Syed Ahmad, my main supervisor for his never ending support and guidance toward the completion of this thesis. Thank you. My gratitude also goes to Associate Professor Gs. Dr. Asmala Bin Ahmad for all the motivation and help. Besides that, I am thankful to my colleagues at the particularly Optimization, Modelling, Analysis, Simulation and Scheduling (OptiMASS) research group for the useful ideas and comments. I am most grateful to the Malaysian Remote Sensing Agency, Department of Agriculture (DOA), Malaysia for providing the data.

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LIST OF ABBREVIATIONS

AHP	-	Analytical hierarchy procedure
ANFIS	-	Adaptive neuro fuzzy inference system
ANN	-	Artificial neural networks
AWEI	-	Automated water extraction index
BIL	-	Band interleaved by line
BIP	-	Band interleaved by pixel
BSQ	-	Band sequential
DOA	-	Department of agriculture
DT	-	Decision tree
ENVI	-	Environment for visualizing images
EROS	-	Earth resources observation system
ETM	-	Enhanced thematic mapper
FCM	-	Fuzzy c-means
FIS	-	Fuzzy inference system
GIS	-	Geographic information system
L1T	-	Level 1 correction
LSWI	-	Land surface water index
LULC	-	Land use/Land cover
MATLAB	-	Matrix laboratory
MIR	-	Middle infrared

ML	-	Maximum likelihood
MNDWI	-	Modified normalized difference water index
MSS	-	Multispectral scanner
NBR	-	Normalized burn ratio
NDBI	-	Normalized difference built-up index
NDMI	-	Normalized difference moisture index
NDWI	-	Normalized difference water index
NIR	-	Near infrared
OA	-	Overall accuracy
OBIA	-	Object based image analysis
OLI	-	Operational land imager
PA	-	Producer’s accuracy
PBIA	-	Pixel based image analysis
RBV	-	Return beam vidicon
RGB	-	Red-Green-Blue
ROI	-	Region-of-interest
SAVI	-	Soil-adjusted vegetation index
SWIR	-	Short-wavelength infrared
SVM	-	Support vector machine
TIRS	-	Thermal infrared sensor
TM	-	Thematic mapper
UA	-	User’s accuracy
UTM	-	Universal transverse mercator
VI		Vegetation index
WGS		World geodetic system

LIST OF PUBLICATIONS

Taufik, A., Ahmad, S.S.S. and Azmi, E.F., 2019. Classification of Landsat 8 Satellite Data Using Unsupervised Methods. In *Intelligent and Interactive Computing* pp.275-284.

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CHAPTER 1

INTRODUCTION

1.1 Research background

As far as remote sensing is concerned, the decryption of the data that is sensed remotely is very vital. The foremost priority is to get accurate data of remote sensing imagery of the maps of the land cover as it is used in several applications involving computations like monitoring of environmental resources and earth surface mapping (Cudahy et al., 2016; Mutanga and Kumar, 2019). The images obtained using remote sensing represent a part of the earth's surface as observed from space. The data from remote sensing is obtained by using various electromagnetic sensors like thermal imagery sensors, aerial photography sensors and hyperspectral sensors. The satellite imagery information from sources like Landsat is decoded by using methods such as image processing, remote sensing and mathematical analysis.

Among the most significant applications of satellite imagery at regional and national level is monitoring the change in the cover or use of land, natural disasters, deforestation and gauging the land boundaries. It is very crucial for nations like Malaysia which is rising swiftly and experiencing huge changes in expansion of land and urban areas. If the use of the land if not properly monitored and managed, it may cause tremendous disasters such as floods in built-up regions, landslides, poverty, and loss of tropical forest regions and biodiversity.

Land cover can be described as the built-up region or vegetation that covers the earth's surface (Anderson, 1976; Islam et al., 2018). In remote sensing, land cover is classified as a particular assignment of pixels in a picture to a specific sort of land cover. The pixels of data assigned then can be utilised to generate land cover's thematic maps. There are two approaches for land cover classification; supervised and unsupervised. Supervised and unsupervised are the two most commonly techniques are used in image classification. Nevertheless, object-based classification (OBIA) has been used recently because it was helpful for high resolution data (Ma et al., 2017).

Maps of the land cover made using remote sensing imagery are used for national and worldwide needs. Malaysia also has put in place the machinery to produce its own maps for showing land cover within its boundaries. It is managed by DOA (Department of Agriculture) since 1966 (Mahmood et al., 1997) and then through an alliance of DOA and MRSA (Malaysian Remote Sensing Agency) which was earlier called MACRES (Malaysian Centre for Remote Sensing), and which is a part of MOSTI (Ministry of Science, Technology and Innovation). The MACRES scheme consists of carrying out research on application, assessment of spatial data obtained from remote sensing and modelling in GIS (geographic information system) technology.

In past several years, there has been a rise in the growth of algorithms and techniques used in interpretation and processing of satellite imagery. The fuzzy approach is one such popular technique. Mapping is commonly reached via the application of a conventional statistical classification, which assigns each image pixel to a land cover class. Such techniques are not suitable for mixed pixels that have 2 or more classifications of land cover, and a fuzzy classification technique is necessary. Although pixels might have several and fractional class memberships according to the strength and, if intensely associated with the structure of land cover, mapped to signify such fuzzy land cover (Foody, 1996; Manjula, Pandiarajan and Jagadeesan, 2014; Kalantar et al., 2017). Recent research based on high resolution satellite (Ferrato and Forsythe, 2013; Lv et al., 2019).

This research focuses on methods of classification using the indices from feature extraction for remote sensing images. The interpretation of feature extraction from the spectral, temporal and spatial dimensions is to provide accurate and thematic maps. Thus, the comparison between fuzzy supervised and fuzzy unsupervised are presented for a land cover classification development based on the indices. In this study, the comparative study for imbalanced data based on accuracy assessment is also presented.

1.2 Research problems

Due to launches of several satellites having different resolutions, (Denis et al., 2017; Burleigh et al., 2019), there is a vast amount of data of remote sensing imagery that is to be managed. For the same geographical region, high resolution images, satellite image time series, and hyperspectral images are easily available now (U.S. Geological Survey, 2018). The most crucial requirement of the remotely-sensed data is the division of pixels with respect to land cover use and changes. Nonetheless, existing techniques used for classifying mixed pixels in remotely-sensed imagery are not too efficient due to the homogenous category (Choodarathnakara et al., 2012; Dewi et al., 2016; Li et al., 2017). In particular, the information appropriate for the purpose of classification can get lost due to huge amount of data flow in the classification of remotely-sensed images (Lv et al., 2019). The research problems (RP) are summarized as follows in Table 1.1.

Table 1.1: Summarization of research problem

No	Research problems (RP)
RP1	The important information for the classification purpose might be hidden by the full set of features in classification of remote sensing images.
RP2	Existing methods defined for mixed and uncertainty pixels are not scale well.

1.3 Research questions

Therefore this study attempts to investigate and answer the questions and issues as follows:

1. How features extraction affects into land cover imagery classification?
2. How to perform imaging land cover classification for mixed and uncertainty pixels?
3. How to evaluate the classification using fuzzy approach?

1.4 Research objectives

This study embarks on the following objectives:

1. To generate and construct features extraction from remote sensing images for supervised and unsupervised classification.
2. To construct and compare fuzzy modelling supervised and unsupervised classification.
3. To compare and evaluate several fuzzy approaches.

Table 1.2 shows the summary of problem statements, research objectives and research questions in tabulated form. This table is represented to point out their correlation together with the anticipated outcomes for each problem statement.