UNIVERSITI PUTRA MALAYSIA

INTEGRATION OF OBJECT-BASED IMAGE ANALYSIS AND DATA MINING TECHNIQUES FOR DETAILED URBAN MAPPING USING REMOTE SENSING

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Chairman : Associate Professor Helmi Zulhaidi Mohd Shafri, PhD
Faculty : Engineering

Urban areas consist of a wide range of man-made and natural features, which lead to a high level of spectral and spatial confusions in detecting roofing materials and other urban land cover features. These heterogeneities and confusions result in erroneous thematic maps that use spectral information only. Reliable and new approaches that combine the spectral and spatial characteristics of urban land covers are necessary to extract accurate detailed maps of urban features in different regions.

Airborne hyperspectral images with very high spatial and spectral discrimination capabilities can be considered to characterize urban land-cover classes; however, the frequent use of airborne hyperspectral images is infeasible because of the limited spatial coverage and high cost of data acquisition. Consequently, pan-sharpened WorldView-2 (WV-2) multispectral images with a spatial resolution of 0.5 m were used as the main data for this research, whereas hyperspectral images were included as supplementary data to indicate the productivity of the proposed approach in decreasing the dimensionality of such images.

Object-based image analysis (OBIA) was implemented to delineate urban surface materials. OBIA was performed in a rule-based structure that requires selecting and identifying rules. In a subsection of the thesis, OBIA was supported by including ancillary information, such as LiDAR data.

The reproducible and transferable novel models were proposed based on (1) user-defined OBIA rule sets and (2) data mining (DM) techniques. In the first case, the rule sets were manually developed from the first study site and then

transferred to the second study site, which had a wider coverage. Overall accuracies of 88.05% and 87.78% were achieved for the first and second study sites, respectively. In the second case, available training data from the first study site were used to conduct the DM task. The proposed OBIA rule sets were automatically organized from the C4.5 algorithm to form a decision tree structure that explores a wide range of spectral, spatial, and textural attributes. The rule-based classification of the first study site obtained an overall accuracy of 87.90%. Finally, the generated model was validated in the second study site to prove that its performance was reproducible and applicable to an area with a wider geographic coverage. This transferability analysis was performed without including any training data from the second study site and an overall accuracy of 85.16% was achieved.

Apart from the analysis of the transferability of OBIA rule sets, this thesis contained two subsections. First, the OBIA of a WV-2 image and LiDAR height information was employed to improve urban surface material classification. This data integration resulted in an improvement of 7% in the overall classification accuracy of the WV-2 image. Second, the dimensionality of OBIA attributes in hyperspectral images was reduced. Numerous OBIA attributes were explored using the C4.5 algorithm on the Universiti Putra Malaysia (with 20 bands) and Kuala Lumpur (with 128 bands) hyperspectral images. These images obtained overall accuracies of 93.42% and 88.36%, respectively.

The manually developed OBIA rule-sets achieved the transferable land cover classification in different areas. In this research, to eliminate the manual developments of the rule-sets, the supervised DM technique was used to identify the appropriate selection of attributes for object-based classification. This algorithm represents the decision tree knowledge model, enables fast classification of intra-urban classes, and disables subjectivities related to the interaction with analysts. The proposed integration of DM algorithm and OBIA provides the opportunity to generate the transferable OBIA rule-sets based on the available training area which can be re-used in other study areas. The generated rule sets can be applied in different WV-2 images to extract similar land-cover environments by providing an automated procedure. Furthermore, supervised DM-based DT overcomes complexities related to a high level of dimensionality in hyperspectral OBIA attributes and the bias of analysts in creating rule sets. The OBIA enhancement of WV-2 image was performed by adding LiDAR height information as an ancillary data. LiDAR data was effective to improve the productivity of OBIA and reduce the complexity of the OBIA rule-sets. The detailed land cover maps of this study could support the environmental applications related to water quality assessment, urban microclimate and urban health assessment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

INTEGRASI ANTARA ANALISIS IMEJ BERASASKAN OBJEK DAN TEKNIK PERLOMBONGAN DATA UNTUK PEMETAAN BANDAR SECARA TERPERINCI MENGGUNAKAN PENDERIAAN JAUH

Oleh

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Ogos 2015

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Kawasan bandar terdiri daripada pelbagai ciri-ciri buatan manusia dan semula jadi, yang membawa kepada tahap kekeliruan spektrum yang tinggi dalam proses mengenalpasti bahan bumbung dan lain-lain butiran litupan bumi di kawasan bandar. Kepelbagaian butiran dan kekeliruan yang berlaku telah menyebabkan kesalahan pada peta tematik yang hanya menggunakan maklumat spektrum sahaja. Oleh itu, pendekatan baru dan boleh dipercayai yang menggabungkan ciri-ciri spektrum dan spatial litupan bumi di kawasan bandar adalah perlu untuk mengekstrak secara terperinci dan tepat perincian bandar di kawasan-kawasan yang berbeza.

Imej hyperspectral bawaan udara dengan ciri spatial dan keupayaan mendiskriminai spektrum yang sangat tinggi boleh digunakan untuk perincian kelas-kelas litupan bumi di kawasan bandar; Walau bagaimanapun, penggunaan imej hyperspectral bawaan udara adalah tidak praktikal kerana ia mempunyai liputan spatial yang terhad dan kos pemerolehan data yang tinggi. Oleh itu, data imej multispectral ‘pan-sharpened’ Wordview-2 (WV-2) yang mempunyai resolusi spatial 0.5 m telah digunakan sebagai data utama dalam kajian ini. Manakala imej hyperspectral telah dimasukkan sebagai data tambahan untuk menunjukkan produktiviti kepada pendekatan yang dicadangkan dalam mengurangkan kedimensian imej tersebut. Analisis imej berasaskan objek (OBIA) telah dilaksanakan untuk menggambarkan bahan permukaan di kawasan bandar. Teknik OBIA ini dilaksanakan menggunakan struktur berasaskan peraturan yang memerlukan pemilihan dan pengenalpastian peraturan. Di dalam subseksyen tesis ini, OBIA boleh disokong dengan memasukkan maklumat tambahan, seperti data LiDAR.

Dalam kajian ini, model baru yang boleh diulang dan dipindah milik telah dicadangkan berdasarkan (1) set peraturan OBIA yang ditentukan oleh pengguna dan (2) teknik perlombongan data (DM). Dalam kes pertama, set peraturan telah dibangunkan secara manual dari kawasan kajian pertama dan kemudian dipindahkan ke kawasan kajian yang kedua yang mempunyai liputan lebih luas. Ketepatan keseluruhan sebanyak 88.05% dan 87.78% telah dicapai untuk kawasan kajian pertama dan kedua. Dalam kes kedua, data latihan yang diperoleh dari kawasan kajian pertama telah digunakan untuk mengendalikan tugas DM. Peraturan set OBIA yang dicadangkan telah disusun secara automatik dari algoritma C4.5 untuk membentuk struktur pepohon keputusan yang meneroka pelbagai atribut seperti spektrum, spatial, dan tekstur. Ketepatan keseluruhan untuk klasifikasi berasaskan peraturan di kawasan kajian yang pertama ialah 87.90%. Akhir sekali, model yang dihasilkan telah diuji di kawasan kajian yang kedua untuk membuktikan bahawa tahap pencapaiannya boleh diulang dan boleh diaplikasi kepada kawasan yang mempunyai liputan geografi yang lebih luas. Analisis kebolehtukaran ini dilakukan tanpa memasukkan sebarang data latihan dari kawasan kajian kedua dan ketepatan keseluruhan sebanyak 85.16% telah dicapai.

Selain daripada analisis pindah milik daripada set peraturan OBIA, tesis ini juga mengandungi dua subseksyen. Subseksyen yang pertama menunjukkan OBIA daripada imej WV-2 dan maklumat ketinggian LiDAR telah digunakan untuk memperbaiki klasifikasi bahan permukaan di kawasan bandar. Integrasi antara data tersebut telah menunjukkan peningkatan keputusan klasifikasi, di mana ketepatan keseluruhan untuk imej WV-2 telah meningkat sebanyak 7%. Kedua, kedimensian atribut OBIA dalam imej hyperspectral telah berkurang. Kebanyakan atribut untuk OBIA telah diterokai menggunakan algoritma C4.5 pada kawasan Universiti Putra Malaysia (dengan 20 jalur) dan imej hyperspectral Kuala Lumpur (dengan 128 jalur). Imej-imej ini masing-masing memperoleh ketepatan keseluruhan sebanyak 93.42% dan 88.36%.

Set peraturan OBIA yang telah diperoleh secara manual boleh dipindah guna kepada aplikasi klasifikasi di kawasan kajian yang lain. Dalam kajian ini, untuk menyingkirkan pembangunan set peraturan secara manual, algoritma DM telah digunakan untuk mengenal pasti pilihan atribut yang sesuai untuk pengelasan berasaskan objek. Algoritma ini mewakili pengetahuan model pepohon keputusan yang membolehkan klasifikasi yang cepat untuk kelas antara bandar dan melumpuhkan kesubjektifan yang berkaitan dengan interaksi dengan penganalisis. Oleh itu, cadangan integrasi antara algoritma DM dan OBIA telah memberi peluang untuk menghasilkan set peraturan OBIA yang boleh dipindah guna berdasarkan kawasan latihan sedia ada dan boleh digunakan semula dia kawasan kajian yang lain. Set peraturan yang dihasilkan boleh diaplikasi pada imej WV-2 yang lain untuk tujuan pengekstrakan persekitaran litupan bumi yang sama dengan menyediakan prosedur automatik. Tambahan pula, 'supervised' berasakan DM DT mengatasi kerumitan yang berkaitan dengan tahap dimensi yang tinggi pada atribut OBIA hyperspectral dan juga masalah berat sebelah penganalisis dalam mewujudkan set peraturan. Penambahbaikan OBIA pada imej WV-2 telah dilakukan dengan menambahkan informasi ketinggian dari data LIDAR. Data

LIDAR merupakan data yang efektif untuk menambahbaik produktiviti OBIA dan mengurangkan kerumitan pada set peraturan OBIA. Pemetaan litupan tanah secara terperinci yang diperoleh dari kajian ini boleh digunakan untuk menyokong aplikasi terhadap alam sekitar yang berkaitan dengan penilaian kualiti air, mikroiklim kawasan bandar dan penilaian kesihatan di kawasan bandar.

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I certify that a Thesis Examination Committee has met on 18 August 2015 to conduct the final examination of Alireza Hamedianfar on his thesis entitled "Integration Of Object-Based Image Analysis And Data Mining Techniques For Detailed Urban Mapping Using Remote Sensing" 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 Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

AISA	Airborne Imaging Spectrometer for Applications
AVG	average
CIR	color infrared
et al.,	et alia
etc	et cetera
EPA	Environmental Protection Agency
DAFE	Discriminant analysis feature extraction
DBDF	Decision boundary feature extraction
DEM	Digital elevation model
DM	Data Mining
GNSS	Global navigation satellite system
Gm/l	milligram per liter
KL	Kuala Lumpur
LiDAR	Light detection and ranging
DSM	Digital surface model
LST	land surface temperature
m	meter
MAX	maximum
MIN	minimum
MIVIS	Multispectral infrared and visible imaging spectrometer
ML	Maximum Likelihood
NDBC	Normalized difference blue and coastal
NDGR	Normalized difference green and red edge
NDN2C	Normalized difference NIR2 and costal
NDNB	Normalized difference NIR1 and blue
NDRR	Normalized difference red edge and red
NDRY	Normalized difference red edge and yellow
nDSM	normalized digital surface model
NDVI	Normalized difference vegetation index
NDVI2	Normalized difference vegetation index_2
NIR	Near infrared
NWFE	Nonparametric weighted feature extraction
OBIA	Object-based image analysis
SAM	Spectral Angle Mapper
STD	standard deviation
SVM	Support Vector Machine
TX	Texture
UHI	urban heat island
UPM	Universiti Putra Malaysia
US	United States
VHR	Very high resolution
WV-2	WorldView-2
WV-3	WorldView-3

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Globally, more people occupy urban areas than rural areas. In fact, 54% of the world's population in 2014 was found in urban areas. By 2050, 66% of the world's population is expected to live in urban areas. Numerous structures have been constructed over the last few decades. Malaysia is one of the countries that is experiencing a rapid urbanization rate (Yaakup et al., 2005). Over 70% of the population in Malaysia has been projected to live in urban areas from 2010 to 2015, particularly in Peninsular Malaysia (Abazov, 2009). The rapid increase in the number of man-made structures can be considered a sign of urbanization and the rapid conversion of natural environment into man-made features (also known as impervious surfaces). The extensive range of man-made and natural urban surface materials can influence ecological (Arnold & Gibbons, 1996), climatic, and energy (Oke, 2002) conditions. Recent changes in urban areas should be identified in detail to improve management and sustainable planning of urban expansion. Consequently, urban mapping must provide accurate information on features, structures, and geography, as well as on the relationships between features in urban and suburban areas (Shafri et al., 2012). Therefore, new methods are necessary to replace traditional field observation and the acquisition of detailed information on the coverage of man-made and natural features.

Remote sensing technology provides the opportunity to collect data from urban land use/cover without direct contact with the features. This technology can be considered an alternative to traditional field survey. The development and availability of very high resolution (VHR) sensors have opened a new prospect in the remote sensing community to monitor imperviousness and natural features effectively at the fine and detailed scale.

The urban environment comprises a wide range of impervious features and natural surface materials. The detailed mapping of urban areas has received considerable attention in the last decades because of the challenges and requirements of parcel-level information in fine-scale decision making and management.

An impervious surface (also known as an impermeable feature) is defined as a surface where water cannot penetrate soil, such as road pavements, sidewalks, roofs, and parking lots. These surfaces are considered major contributors to environmental condition and quality (Arnold & Gibbons, 1996;

Weng, 2012). In the present study, methodologies for detecting detailed urban land covers, including different roofing materials, roads, and natural land covers, are proposed. Detailed knowledge on the distribution and types of imperviousness is vital in recognizing the effects of man-made structures on a natural surroundings. For example, roofing types can contribute to status of health, pollution, and microclimate. Asbestos rooftops cause a critical health hazard. Recent researches have highlighted mesothelioma as a type of cancer that caused by the exposure to asbestos materials (Egilman & Menéndez, 2011; Kanarek, 2011). Roof runoff pollution deteriorates urban surface water quality. Previous researchers have identified roofing runoff as one of the substantial pollutants in streams and rivers (Göbel et al., 2007; Slonecker et al., 2001; Yusop et al., 2007). Urban growth has caused variations in the patterns of air temperature in urban areas. Dark impervious features, such as concrete and metal roofs, and pavements, absorb significant quantities of heat and release it to the environment (Elsayed, 2012). Appropriate urban planning, which require comprehensive knowledge of urban surface materials, should be employed to ensure the well-being status in an urban environment.

VHR images are required to characterize urban land cover at the material level (Zhou & Troy, 2008). Such images can be acquired using airborne hyperspectral and multispectral sensors. The supervised classification of urban surface materials at the material level requires adequate training data. Collecting training data on roofing types is one of the limitations in material characterization because of the restricted access to roofs and the difficulty in obtaining permission in many areas. Prior to this research, numerous studies have used airborne hyperspectral images to detect urban surface materials (Ben-Dor et al., 2001; Heiden et al., 2001; Heiden et al., 2007; Herold et al., 2003b; Taherzadeh & Shafri, 2011). This choice can be attributed to the very high spectral resolution of hyperspectral data, which provides detailed spectra and narrow bands compared with broadband-width multispectral images (Platt and Goetz, 2004). However, the limited coverage of airborne hyperspectral images and the high cost of data acquisition add to the challenges in characterizing surface materials.

In this study, VHR multispectral WorldView-2 (WV2) images were used to detect urban surface materials. With the improvement in sensor technology from IKONOS, QuickBird, GeoEye-1, and recently, WV2 and WorldView-3 (WV-3), identifying small sized land covers such as buildings, vehicles, parking areas, and pavements is possible. Analysts tend to consider spatial resolution more important than spectral resolution (Myint et al., 2011) because the detailed characterization of urban surface materials (with impervious and pervious surfaces) requires high spatial discrimination. Previous studies have employed IKONOS, QuickBird, and GeoEye-1 to detect urban classes under a general classification scheme, which excludes details on material type. These remotely sensed data are limited to four spectral bands, which can lead to restrictions and confusion in detailed land-cover classification. WV2 was the first accessible VHR multispectral satellite containing eight bands. WV2 images provide stronger spectral discrimination because of their sharper multispectral bands, which results in more detailed information on urban surface materials.

Image analysis of VHR data is difficult because of the spatial and spectral heterogeneities of urban surface materials. Man-made features such as rooftops and road asphalt have the same component materials, which causes a high degree of spectral confusion (Myint et al., 2011). Previous studies have indicated that within-class spectral diversity can be observed among urban targets, and spectral similarities among different classes pose additional difficulties in extracting detailed features (Myint et al., 2011; Zhou & Troy, 2008). These spectral heterogeneities and confusions result in erroneous thematic maps created by spectral-based image classifiers (Blaschke & Strobl, 2001). Restrictions in spectral information cause failure in accurately mapping urban classes despite the automated procedure and reduced effort required by spectral-based classifiers (Aplin et al., 1999; Blaschke, 2010; Blaschke et al., 2014; Blaschke & Strobl, 2001; Whiteside et al., 2011). In addition, selecting reliable training data is a time-consuming task because repeated training samples are required to classify additional areas of the same image, which are not transferable to new images. Object-based image analysis (OBIA) has been proven as a better alternative for analyzing VHR images. Compared with spectral-based methods, various studies have demonstrated the superiority of OBIA in terms of high quantitative accuracy and improved qualitative accuracy. OBIA utilizes spectral characteristics along with textural and spatial characteristics to avoid problems related to traditional pixel-based classifications. OBIA can be performed under a supervised approach that requires training segments of pixel groups. Moreover, OBIA can be performed under knowledge-based (rule-based) rule sets, which allow transferring rule sets to other images with similar land cover classes.

Nevertheless, prior knowledge, which is difficult to obtain, is required to detect feature classes by rule-based classification. Fully formalizing relevant information and effectively reusing them in other images is time-consuming because rule-based classification mostly addresses the experience and interaction of analysts. Therefore, the lack of transferable rule sets can be observed in literature. A previous study (Taherzadeh & Shafri, 2013) defined the generic OBIA rule sets for roofing types within a limited coverage of urban areas, which cannot be considered a transferable approach. Several studies have demonstrated the transferability of urban classes by including manual editing of rule sets (Kohli et al., 2013; Taubenböck et al., 2010). However, few studies in literature have explored urban mapping at the material level using VHR multispectral images with a wide spatial coverage. Furthermore, transferable and reproducible approaches that effectively utilize spatial, spectral, and textural information inherited from VHR images are still unable to perform remote sensing of urban surface materials.

At present, apart from VHR image data, other geospatial and geographic data, such as LiDAR, road, land use, and parcel data are available to support image analysis. Several studies have used LiDAR data and its products, such as high-resolution digital surface model (DSM), normalized digital surface model (nDSM), and digital elevation model (DEM), as ancillary information to reduce the spatial and spectral heterogeneities of urban areas. Ancillary data can help improve results in land cover classification.

In case of OBIA of hyperspectral images, difficulties in attribute extraction and the dimensionality of OBIA attributes make rule-based classification a complex and time-consuming process (Cavalli et al., 2008). Hyperspectral data analysis was considered a supplementary section of this thesis to mitigate the complexities caused by data directionality in rule-based OBIA. Airborne hyperspectral images with pixel sizes of 1 m and 0.68 m were considered for urban surface material classification.

1.2 Problem Statement

Urban areas consist of spectrally and spatially heterogeneous features. Very high resolution remotely sensed images provide wealth amount of information on spectral and geometrical characteristics regarding urban land cover environment. This detailed information gives more challenges for material-level land cover classification. Obtaining detailed land cover maps from VHR data will require not only the development of tools for efficient data analysis, but also improved feature extraction accuracy. Spectral-based (pixel-based) images classification techniques are not effective enough to handle these data due to the restriction on spectral information. Furthermore, these techniques are not spatially transferable because of the necessity to collect training area (region of interest) within different study sites. In recent years, although rule-based OBIA has been proven as an effective alternative for traditional spectral-based classifiers, there are some challenges with regard to this advanced image classifier. Since this technique requires lots of manual interactions for the image analyst in rule-sets development, it is time consuming and difficult to transfer the rule-sets to another images even from the same multispectral sensor. This may cause manual adjustment in the structure of OBIA rule-set. Furthermore, considering hyperspectral images with huge number of bands, it is time consuming and labor intensive to manually select the best combination of OBIA attributes in the rule-set development. Therefore, it is important to design and develop new methodologies for transferable mapping of multispectral VHR images and dimensionality reduction of hyperspectral images in rule-based OBIA. In addition, considering a complex urban environment, because of the diverse spectral and spatial heterogeneity, unclassified objects or misclassifications in the boundary of land cover classes could occur. Therefore, multi-sensor data fusion could be also considered to enhance the classification output.

1.3 Research Objectives

In general, this research investigates VHR remote sensing data in characterizing urban feature classes (with emphasis on roofing types) at the material level and proposes transferable models based on the spatial, spectral, and textural information of large-coverage WV-2 satellite.

Meanwhile, the specific objectives of this research are as follows:

- To develop a fusion-based OBIA technique that utilizes LiDAR and WV-2 data to improve urban surface material mapping; and

- To design and validate transferable OBIA rule sets to other study areas with wider coverage using WV-2 images;

- To utilize the integrated OBIA and DM technique for airborne hyperspectral data over urban areas.

1.4 Scope and Limitations of the Study

This study aims to characterize detailed urban land covers at material level according to transferable urban land cover mapping, data dimensionality reduction, and classification result enhancement. Transferable urban land cover classification was employed based on WorldView-2 satellite images. For data dimensionality reduction, airborne hyperspectral images were investigated due to the large number of spectral bands. Enhancing of the classification result was performed by the data fusion of WorldView-2 image and LiDAR data. In this study, detailed urban land cover classes of metal roofs, dark concrete/asbestos roofs, medium tone concrete roofs, roads, bare soil, pond/river, swimming pool, grass, trees, and shadow were considered. The limitation of the study was the limited spatial coverage of hyperspectral images (with different number of bands) and LiDAR data. Therefore, the transferability analysis of urban land cover classes were not performed for the hyperspectral images and the data fusion of WorldView-2 image and LiDAR data.

1.5 Organization of the Remaining Chapters

The second chapter is the literature review section. This chapter presents the definitions of remote sensing technology, urban remote sensing, and impervious surface, as well as the application of VHR multispectral and hyperspectral data to achieve a detailed characterization of urban areas. This chapter also discusses current trends in image analysis, including pixel-based techniques and OBIA. The summary and gaps of previous studies are discussed in the last part of the chapter.

The third chapter presents the materials and methods used to achieve the objectives of this research. The first section of this chapter discusses the methodologies applied in the WV-2 image, including spectral-based classification techniques [e.g., maximum likelihood (ML) and support vector machine (SVM)] and the developed OBIA techniques and models to classify urban surface materials. The section continues to discuss the characteristics of the LiDAR data used in the study and its integration with the WV-2 image in OBIA to improve OBIA conducted using only the WV-2 image as well as spectral-based classification using the WV-2 image fused with LiDAR data. The next section of this chapter discusses the developed OBIA technique based on transferable models from WV-2 images. The last part of this chapter focuses on hyperspectral data analysis using OBIA to extract urban surface materials.

The fourth chapter presents the results and discussion of the study. The first section discusses the results and discussion of the WV-2 image, including those of spectral-based methods (ML and SVM) and the developed OBIA techniques. The next part of this section describes the improvement of the OBIA result when LiDAR data are added to the WV-2 image. In addition, the results of the spectral-based techniques (SVM and ML) using the fused data sets of WV-2 and LiDAR are also provided. The results and discussion of determining transferable OBIA approaches using different WV-2 images are presented. The last part of this chapter presents the results and discussion of the hyperspectral images from the automated OBIA classification.

The fifth chapter provides the conclusions drawn from the study and recommendations for future research. The overview and implications of the findings, as well as the limitations and benefits of this research, are discussed. Finally, the future research direction is explained in the recommendation part of the chapter.

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