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FACULTY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF SURVEYING AND GEOMATICS

THE USE OF OBJECT ORIENTED IMAGE ANALYSIS AUTOMATIC EXTRACTION OF UNPAVED ROADS IN UPDATING ROAD MAPS: A LESSON FOR THE DEPARTMENT OF THE SURVEYOR GENERAL

Submitted By

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Dissertation submitted in partial fulfilment of the Bachelor of Science Honours Degree in Surveying and Geomatics

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The undersigned certify that they have supervised the student Zvatapiwa Moyo in a dissertation entitled, "The use of Object Oriented Image Analysis (OOIA) automatic extraction of unpaved roads in updating road maps: A lesson for the Department of the Surveyor General", submitted in partial fulfillment of the requirements of the Bachelor of Science Honours Degree in Surveying and Geomatics at the Midlands State University.

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Phase 1

Gweru

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Above all, I thank the Lord. For all what is impossible with man is possible with God. (Luke 18 verse 27)

Dedications

I want to dedicate this thesis to my late mother. You will always be missed, rest in power.

Abstract

This paper exhibits a method for extraction of unpaved roads from high resolution Pleiadis satellite imagery using Object Oriented Image Analysis (OOIA). The study area is Woodlands in Gweru Zimbabwe. Using ENVI EX, a rule based classification was performed. Classification rules were made from unpaved roads properties, by utilizing combination between unique multispectral bands, principal components and also utilizing combination of geometric attributes like width, length, neighbor and asymmetry and contextual ones. The outcome demonstrates that the OOIA algorithm effectively extracts unpaved roads from satellite images.

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CHAPTER ONE

1.0 Introduction

Object-based image analysis (OBIA) is one of the most recent innovations in image classification approaches (Blaschke, 2006). As opposed to the customary pixel-based techniques situated in light of the thorough analysis of spectral data per-pixel, OBIA commonly incorporates both spectral and spatial data amid the image segmentation stage. The procedure includes subdividing the image into homogenous locales with comprehensively comparative pixels or fragments in view of spectral and spatial qualities, and after that arranging them progressively into image objects (Benz *et al.*, 2004). When image objects are made, any classification calculation can be utilized to characterize the objects. Jensen (2009) investigated that OOIA has the benefits of coordinating more object related features than pixel-based methodologies, to speed the handling time and diminish the "salt and pepper" impact on classifications. OOIA also produces maps with higher accuracies (Wang *et al.*, 2016).

There is a growing interest in spatial information; and this has resulted in a parallel growth in the use of aerial photogrammetry in topographic mapping. Ongoing advances in computer vision and machine insight has prompted the improvement of new systems, for example, OOIA for programmed content extraction of both man-made and natural geospatial objects from remote detecting of images. The improvement of object- oriented classifications techniques appropriate for medium to high resolution satellite imagery gives a legitimate other option to 'conventional' pixel-based techniques.

OOIA, a platform for integration of different types of data (spectral, elevation and thematic), has officially demonstrated its capacity for effective automatic grouping of landforms (Tapas Ranjan, 2011). An article published by Badjana *et al* (2015) states that there is high rate of changes in urban areas which requires the presence of coordinating geographic data with a specific end goal to empower legitimate land monitoring and planning. At the point when cartographic data exists, yet is out-dated, a change detection methodology utilizing advanced geographic information can be applied for map up-dating. Thus the goal of this work is to present an OOIA methodology that enables unpaved roads to be ascertained and further mapped, using Very-High Resolution (VHR) imagery for the betterment of the Department

of the Surveyor General (DSG). The features of interest chosen for extraction are unpaved roads.

1.1 Background and Justification

According to an article, by Japan international cooperation agency (2012), the last topographic maps of the 1:5000 scale for the Harare and its environs were produced in 1985 from aerial photography acquired in 1985. Detail metadata on spatial status particularly huge scale topographic maps are the spine for sustainable development, for example, infrastructure, transport systems, crisis administration, power supply, sanitation and wellbeing. Road systems are essential highlights in geospatial databases. Despite the fact that high-resolution optical satellite images have just been acquired for over 10 years, apparatus for computerized extraction of road systems from these images are as yet uncommon (Context *et al.*, 2016). One consequence of this is the need for manual interaction which, in turn, is time and cost effective. Likewise geospatial data advancements have turned out to be basic devices to assist in national and global innovation, monetary development, decision making and future planning. System of paved roads can be noticeably depicted in high resolution satellite images, which makes paved roads extraction a simple assignment. In any case, practically no accentuation has been laid on the extraction of unpaved roads. Advancement of procedures for the extraction of unpaved roads can be extremely useful and accommodating in security and reconnaissance (Technology, 2016).

United Nations (2013) brings up that proof is mounting that fast urbanization, particularly in developing nations, calls for real changes in the manner by which urban advancement is planned and overseen, and additionally considerable increments of open and private interests in urban framework and administrations. Roads are a key part of transportation frameworks and have a place with the foundation of modernization. They are noteworthy in both the military field and normal everyday living. With the advancement of the remote sensing innovation, programmed road extraction from remote sensing images has turned into an essential subject in computerized digital photogrammetry (Wang *et al.*, 2013).

The Department of the Surveyor General is solely responsible for the mapping production and distribution. Since most of the produced maps are kept in paper format, this has led to

the stocks of the maps pilling up and taking much storage space at the stores section. Whilst they are piling up in cabins, spatial data on the physical ground will be changing rapidly which in turn renders the archived maps being out- dated. Adopting high technological instruments such as Unmanned Aerial Vehicles (UAVs) to continuously update the maps at the DSG is being hindered by financial crisis in the government. This has led the DSG to resort to affordable methods such as digitizing of roads and road surveys (using confiscated Computer Aided Drawing software such as SURPAC and AutoCAD) of updating maps. However these methods being opted for are manual and solely depend on human interaction with the software to correctly and precisely update maps. Using this background, it is essentially necessary for the DSG to shift from manual methods to automatic or semi-automatic methods to improve its cartographic products in terms of accuracy and reliability at the same time incorporating affordability.

1.2 Problem definition

According to Sori (2012), changes to the landscape are constantly occurring both naturally and human induced. It is fundamental for these progressions to be consistently recognized and updated for refreshed topographic data keeping in mind the end goal to mirror the present status of the landscape. Most national maps in Africa are old, obsolete, and to a great extent exist in manual form. Because of the high cost of aerial photography, these maps have not been updated for a long time and accordingly are not valuable for planning and routing purposes. Along these lines, there is an earnest need to create new maps or update existing ones (Ottichilo, Khamala and Sensing, no date).

Zimbabwe is a developing country. In that same vein of development, roads are rapidly under construction especially in the rural areas. However mapping of these unpaved roads has been less considered and no full technological input has been injected into related projects. The urgent need to update maps is the lack of coherence between the map and reality hence resulting to bias. Most clients brought in complains that they have accessed out-dated maps from the DSG posing threats of loss of resources in conducting proper planning in case of physical land development. The cash stricken department is failing to hire or train technical people to manually produce highly demanded updated maps. Human intervention in updating old maps should be shunned as it is costly and susceptible to human

error and blunders. In doing so, automatic methods such as OOIA should be adopted forthwith to precisely update old maps (particularly unpaved road maps) at the DSG in order to meet the demands of the rapid developments in the country.

1.3 Research Questions

I.   Can texture based OOIA technology provide optimum results in delineating unpaved roads from satellite imagery.

II.   Is it possible to differentiate mixed features with similar characteristics using OOA, if so, to what extent?

1.4 Research Objectives

1.4.1 Main Objective

To develop a set of rules for application in Object Oriented Image Analysis (OOIA) in updating the old maps, unpaved roads in particular at the Department of the Surveyor General in Zimbabwe; Case Study: Woodlands, Gweru.

1.4.2 Specific Objectives

I.   Performing a rule based classification using ENVI X in extracting unpaved roads from Pleiadis satellite images.

II.   To test the segmenting of an image into regions of pixels based on computed region attributes for each region.

III.   To classify the objects with rule-based classification.

IV.   To validate the OOIA algorithm performance.

CHAPTER TWO

Literature Review

2.1 The basic theory of Remote Sensing

Remote sensing is the science and craft of getting data around an object, area, or phenomenon through the examination of data procured by a device that is in not contact with the object, area, or phenomenon under scrutiny. The device is a remote detecting sensor that is worked from airborne and space borne platforms to help with reviewing, mapping and monitoring the earth's features (Yan, 2003). Remote detecting sensor procures information of different earth surface features that radiate and reflect electromagnetic energy, and the information is analyzed to give data about the resources under scrutiny. All the more as of late, commercial remote detecting innovations and techniques are presented in transportation practices. Components from satellite images, for example, roads, railways, drainages, water bodies, vegetation and other curvilinear structures have been extracted through different systems from satellite images (Wang J. and Zhang, Q., 2000). Quackenbush (2004) reiterates that the availability of a high resolution satellite images has offered ascend to extraction of road networks and this has earned much consideration. Numerous applications ranging from transportation planning, activity administration, routing services, geographical based services, and fleet management use advanced digital road data. Remote sensing imagery, with its recently upgraded spatial, spectral and temporal resolution, gives more subtle elements of the earth surface and takes into account exact and reliable detection and characterization of the terrain and the sequences of earth with higher accuracy along these lines additionally advantage the transportation applications (Zhang, 2010).

The automatic extraction of man-made structures, for example, structures and road from advanced digital imagery has been a point of convergence of photogrammetric and image preparing research for as long as 20 years (Barry, Rüther and Barry, 2004). Updating road maps (or other types of maps) is a time-consuming operation when performed manually. Unfortunately, no existing methods allow complete and reliable automation of this process (Fortier et al., no date). Thus much effort is devoted to finding solutions to this problem.

Remotely sensed imagery, for example, aerial photographs, low altitude aerial photographs (e.g., from drones/unmanned aeronautical vehicles), satellite imagery, Light detection and Ranging (LiDAR) data, has been used to map roads utilizing a few methodologies. These techniques incorporate basic yet knowledge requesting manual image analysis, photogrammetry utilizing stereo-photographs or stereo - images, and semi-automatic/programmed feature extraction utilizing pixel, sub-pixel, or OOIA (Chalapathi, 2015).

According to Hofmann (2004), a standout amongst the most imperative parts of understanding imagery is data about image context. There are two kinds of relevant data: global context, which portrays the circumstance of the image, essentially time, sensor, location and local context, which depicts the shared connections of image regions. In human discernment, handling of context data is by and large intentionally or intuitively present and contributes basically to the immense capacities of people in image analysis. Keeping in mind the end goal to get significant contextual information, image regions of the correct scale must be brought into connection. Human visual discernment techniques for OOIA make it conceivable to analyze an image in view of: pixels gathered to meaningful objects, contextual data by considering neighborhood connections and various scales by producing objects of various size (Gmbh and Munich, 2001). To create helpful image objects, appropriate image segmentation is indispensable for the entire investigation process. To benefit by contextual information the objects need to wind up mindful of their neighborhood. Considering the diverse estimated objects ought to be composed progressively.

2.2 Paradigm shift of feature extraction (manual-semi-automatic feature extraction)

One of the main objectives of Geoinformatics engineering is to collect data and analyze, represent the products of these data with diverse means. Today, the reliable production of information and its rapid serve to the user community is an important task. The rapid aspects of data arrangement have quickened the advance of innovation. Because of this stormy advance information securing from space has been an operational concern. Extracting both geometric and semantic data from space images has been the principle concern since the early period of remote sensing (Sahin et al., 2004).

Road feature extraction methods can be widely classified as semi-automatic method and fully automatic method (Wijesingha et al., 2012). But there is no technique for complete automatic road feature extraction from imagery, there might be in any event minimal human interaction in all the present feature extraction techniques. Magnitude of data in the space images drives the user to digitize the relevant objects at hand. The key issue in automatic object extraction is reliable object identification. Hu, Zhang and Tao (2004) ascertained that in recent years the human machine cooperation strategy for object extraction has been an active research area. In this strategy, the object of interest is first identified by a human operator and some seed points are often provided, the object is then delineated automatically and accurately by the computer algorithm. This is also called semiautomatic extraction. The bottle-neck issue in recognizing the object is in this way eliminated, and the given approximations fill in as solid imperatives to control the extraction procedure, offering more reliable and more exact extraction result. The semi-automatic technique endeavors to coordinate the knowledge of our human visual framework with a capacity to perceive the object robustly and the computer system with a capacity to perform quick feature extraction and precise shape representation. (Hu, Zhang and Tao, 2004).

The use of OOIA on very high resolution data permits to acquire, by an automatic or semi-automatic analysis with a negligible manual intervention- a much better classification in presence of very high determination data of small areas, where there are higher chances of error. In OOIA the semantic level is raised: relation rules join spaces are included, topological data and statistics, thus the context is defined. (Barrile and Bilotta, 2008).

2.3 OOIA versus Pixel based classification

Yan (2003) portrays OOIA as an approach that consolidates spectral data and spatial data. This approach fragments the pixels into objects as per the tone of the image and groups the image by regarding each object all in all. Using the texture and contexture data of the object notwithstanding utilizing spectral information, OOIA has all the more effective image capability Machala and Zejdová (2014) depict OOIA as an approach which can amass moderately homogenous pixels into significant objects based on their radiometric properties and afterward extract meaningful additional data, for example, size, shape, texture or contextual information. OOIA takes into consideration utilization of extra factors such as shape, texture, context, and other cognitive information gave by the image analyst to segment and classify image features, and in this way, enhancing classifications. (Moskal, Styers and Halabisky, 2011).

The use of OOIA on high resolution data permits to acquire, by an automatic or semi-automatic analysis – with a negligible manual intervention - a great order classification very high resolution of little urban areas, where higher is mistake plausibility. In an OOIA the semantic level is raised (Barrile and Bilotta, 2008). To completely exploit the data of high-resolution images, techniques are required which go past conventional statistical analysis and the classification of pixels .In particular, Blaschke and Strobl (2001) contend that great per-pixel classification approaches do not unequivocally make utilization of the spatial qualities inherent inside the image. The essential processing units of OOIA are segments, purported image objects, and single pixels. Points of interest of OOIA are significant statistic and texture computation, an expanded uncorrelated component space utilizing shape (e.g. length, number of edges, and so forth.) and topological highlights and the nearby connection between true real world and image object (Benz et al., 2004). This connection enhances the estimation of the ultimate classification and cannot be satisfied by normal, pixel-based methodologies.

Methodologies based on objects as opposed to pixels, are more qualified for the high heterogeneity found in complex scenes (Santos et al., 2011). Despite pixel based classifiers to being an inconsequential and economical, they are not equipped for exploiting semantic data like shape, pattern, texture, neighborhood context, especially where numerous features have comparable spectral reflectance.

Furthermore, essential information for image understanding is not represented in single pixels yet in significant image objects and their common relations (Blaschke, 2010). OOIA instead does utilize spectral and contextual information in an integrative way.

Pixel based approach uses spectral data of the pixels to classify the image (Wang et al., 2016). Typically the distinctive physical properties of earth objects have diverse spectral information and can be indicated by this pixel based approach. The capacity of this approach is constrained when objects have comparable spectral data thus the image cannot be characterized accurately. Pixel based image classification is an effective to get ' thematic classes' from multi-band images .However, it has certain limitations that should be taken into consideration. The most important constraints of pixels- based .Nonetheless, it has certain restrictions that ought to be thought about. The most critical limitations of pixels-based image classification are that it brings about spectral classes, and that every pixel is assigned to one class only. Spectral classes will be classes that are specifically connected to the spectral bands utilized as a part of the classification are that it results in spectral classes, and that each pixel is assigned to one class only (Tempfli et al.,2001). These are linked to surface characteristics. Pixel-based image classification is that each pixel is only assigned to one class.

Ongoing improvements in remote sensing made it conceivable to get information of a high spatial resolution which permits extraction, assessment, and checking of an expansive scope of possible target features. In the meantime, the demand to automate image analysis in operational conditions is always developing. In any case, the assortment and number of various features to be extracted, include challenges particularly as far as displaying and auto adaptive procedures. The upside of a spatial resolution with pixel sizes fundamentally littler than the normal size of the object of interest comes with the disadvantage of an abundance of spatial detail and the accordingly huge amount of data to be processed. To mitigate this disadvantage, the OOIA approach has turned out to be a contrasting option to the pixel based image analysis (Baatz, Hoffmann and Willhauck, no date).

Customarily remote sensing image analysis has been dependent wholly on pixel based classification methods (Moskal, Styers and Halabisky, 2011). Pixel based classification includes handling a whole scene pixel by pixel while object based classification includes preparing of a scene by analyzing a groups of pixels as objects. While differentiating it to customary pixel-

based methodologies, remote sensing with object based classification methods is accounted for to accomplish enhanced classification results about complex heterogeneous scenes. Sori (2012) built up a classification method which made utilization of the fuzzy pixel-based classification as contribution to object based classifier which utilizes shape, spectral, and neighborhood features to decide the ultimate classification of segmented image. The method, the object based classifier could recognize structures, impervious surface, and roads in thick urban areas with 76%, 81%, and 99% classification accuracies, respectively. All this has been attested by Nobrega and Hara (2012) that automated classification has demonstrated unsatisfactory results when traditional per-pixel classifiers are used.

Mohamad et al. (2015) indicates that OOIA approach yields better results than Pixel based approach and that a combined approach to classification using object based methods and contextual information available about the image, seems promising and needs further exploration. The OOIA workflow has proven in many applications to be useful to extract objects of interest in an automated manner which is not supported by the pixel-based approach (Baatz, Hoffmann and Willhauck, no date). Not only if objects of interest are to be extracted but also if only a correct labeling of regions is requested a pure object-based approach is often limited. On the other hand, OOIA has advantage of improving the quality of classification which cannot be accomplished by traditional, pixel based approach (Benz et al., 2004). Due to these advantages utilized in image analysis, Lang and Blaschke (2000) echoed out a fact that OOIA is commonly considered as the bridging element between Remote Sensing and GIS.

2.4 Unpaved roads attributes

In numerous low pay economies, for example, Zimbabwe, improvement of the rural roads is on-going. Rapid and frequent surveys of the road network development are needed to keep maps up to date and to monitor the potential impacts of road development on agricultural practices and production and other economic development. Transport is crucial to monetary and social improvement in any nation, in a nation like Zimbabwe. There are 88,100 km of classified roads in Zimbabwe, 17,400 km of which are paved ('Additional Zimbabwe Road Network', 1981). About 5 percent of the network is classified as primary roads and has some of the most trafficked arterials that link Zimbabwe with its neighbors. The tertiary access roads, together with the unclassified roads (which happen to be overwhelming unmapped unpaved roads), regularly with

activity volumes under 50 vehicles for each day, accommodate the intra-provincial access developments. They link rural communities to social economic amenities, such as schools, health centers, and markets, and enable government services to reach rural areas.

Roads in an aerial image can be signified based on the following characteristics: radiometric, geometric, topologic, functional, and contextual. Factors such as weather, intensity of light, and orientation of the camera can affect the representation of the road features in an image. This affects the road extraction process. Geometric and radiometric properties of a road are regularly used as initial input characteristics in determining road edge features. Roads are elongated, and in high-resolution aerial images they run through the image as long parallel edges with a constant width and curvature (Ural et al., 2015). In high-resolution images, road region appears as elongated regions with parallel borders. This property can be used to separate road regions from any other spectrally similar objects, such as parking lots, buildings, and crop fields as these non-road objects usually occupy a large and wide area. Constraints on detection based purely on such characteristics comes from the fact that there are other features, like rivers that may be misclassified as roads, if an automated procedure to identify road segments is implemented in an extraction method. This leads to a requirement for the use of additional characteristics when extracting roads. In addition, roads within an image may have different widths, based on their functional classification. This characteristic unaided cannot be used as a parameter in the automatic extraction of a road from an aerial image. Topologic characteristics of roads are based on the capacity of roads to form road networks with intersections/junctions, and terminations (Ziems, Gerke and Heipke, 2007). Roads generally tend to connect regions or centers of activity in images; they may start at a building (e.g., house) and ends at another center of activity, or continue to an end of an image. Roads tend to intersect and to connect to the other roads in an image. Topological information can be used to detect and extract missing segments of roads (Blaschke and Hay, 2001). Absent or blocked road sections could be connected to the extracted fragments based on the topological data of the neighboring segments. Roads are worked to link certain spots together and neighboring roads are associated with form networks. This property is normally utilized as a part of the road network, especially while crossing over gaps. Social and natural features can likewise be utilized as contextual data to extract roads, alongside outside information separated from the data in the image (geometric and radiometric qualities). Relevant data, and data from outside sources, can be utilized to create topologic, utilitarian, and contextual

characteristics. Automatic method of extraction, implemented by Baumgartner et al. (1999) use these characteristics. Singh et al. (no date) points out that roads can also be classified based on their function as being a local road or a highway. This functional information is applicable in determining the width of the road and the characteristics of the pavement that would in turn be used to set the radiometric properties, allowing the road to be identified based on its functional classification. In supporting the extraction process by using this characteristic there is need to be an external source of information characterizing the road, besides the information stored in the image.

System of paved roads can be visibly seen in high resolution satellite images, which makes paved road extraction a simple errand. However, practically no accentuation has been laid on the extraction of unpaved roads (Technology, 2016). According to Gomes, Feitosa and Coutinho (2004), locating unpaved roads in low-resolution satellite images is not a trivial task. Despite the fact that they have the spectral response of uncovered bare soil, their spatial width is regularly far underneath the pixel size. Therefore, the pixels crossed by unpaved roads have a different spectral response over the scene depending on the surrounding pixels. In this manner, the pixels crossed by unpaved roads have an alternate spectral response over the scene relying upon the encompassing pixels The following are general assumptions regarding the characteristics of unpaved roads that are supposedly taken by a human observer into account to locate narrow unpaved roads on an image. Their shading is more like the exposed soil spectral appearance than are the pixels on the two sides of the road, they have medium to large length, and direction changes smoothly along it.

2.5 Methods for road extraction system
The wide range of literature on road extraction involves consideration of many aspects. Researchers focus on various problem definitions, use a variety of data sources, and apply methods spanning a large collection of algorithms.

2.5.1 Mathematical Morphology (Dilation)
The systems of numerical morphology have demonstrated valuable in robotizing feature extraction. In a particular track of calculations, mathematical morphology is utilized to decide

the roads (Soille and Pesaresi, 2002) .Formal morphological tasks are generally used in a consecutive way to perform disentanglement, diminishing, gap filling or noise rectification for extracting the road centerlines. Starting arrangement of the roads from the images might be done utilizing pixel-based. In an object based approach, road portions are first decided at that point to be additionally assessed. (Zhang, 2008).

Mathematical morphology is a hypothesis which gives various helpful instruments for image synchronization, so it has been generally utilized as a part of advanced image handling and spotlights on the territory that reviews the geometric properties of feature objects in the images. This permits the extraction of image features that are valuable in the portrayal and depiction of the shape of a region. (Gonzales and Woods, 2000). In mathematical morphology, images undergo filtering utilizing a kernel. The yield of the filtering procedure relies upon the match between the image and the kernel and the activity being performed (O'Brien, 1989). The two fundamental tasks of numerical morphology are dilation and erosion (Serra, 1986).

2.5.2 Sobel Operator

The Sobel operator is a discrete differential administrator. The administrator uses two 3x3 pieces: one gauges the inclination in the x-bearing, while the other one appraisals angle in the y-course. The operator comprises of a couple of 3×3 convolution bits. The image is convolved with the two parts to rough the subsidiaries in level and vertical change. At each given point, greatness of the angle can be approximated. The kernels can be connected independently to the information picture, to deliver isolate estimations of the angle part in every introduction (call these Gx and Gy). These would then be able to be joined together to locate the supreme extent of the inclination at each point and the introduction of that gradient.

2.5.3 Hough Transformation

The exemplary Hough Transform is a standard calculation for line and circle recognition. It can be connected to numerous computer vision issues as most images contain include limits which can be portrayed by standard bends. The fundamental preferred standpoint of the Hough transformation method is that it is tolerant of holes in boundary portrayals and is generally unaffected by image clamor, like edge detectors. The least complex instance of Hough change is the direct change for distinguishing straight lines. In the image space, the straight line can be portrayed as y = mx + b and can be graphically plotted for each combine of image focuses (x, y).

In the Hough transformation, a fundamental thought is to consider the attributes of the straight line not as image focuses x or y, but rather as far as its parameters, here the slant parameter m and the block parameter b. Hough transformation is a feature extraction method utilized as a part of image investigation, computer vision, and digital image handling. (Shapiro ,2006). It is an automatic analysis technique used for detection of linear features in a variety of applications (Karnielli, et al., 1996).This strategy is robust and has demonstrated to be able to handle noise and occlusion (Aguado, 2002).

2.5.4 Edge Detection

Edge identification is the name for an arrangement of scientific techniques which go for distinguishing focuses in an advanced image at which the image brightness changes exponentially or, all the more formally, has discontinuities. There are numerous techniques for edge location, yet the greater part of them can be gathered into two classifications, seek based and zero-intersection based. The search based techniques, for example (Sobel, Prewitt, Roberts, Canny) distinguish edges by first processing a measure of edge quality, generally a first-arrange subordinate articulation, for example, the inclination extent, and afterward hunting down neighborhood directional maxima of the angle greatness utilizing a registered gauge of the nearby introduction of the edge, for the most part the slope bearing. The zero-intersection based strategies scan for zero intersections in a moment arrange subordinate articulation registered from the image keeping in mind the end goal to discover edges.

Edge detection is a pivotal advancement in object delineation. It is a procedure of discovering sharp discontinuities in an image. The discontinuities are unexpected changes in pixel density which describe limits of features in a scene. To put it plainly, the objective of edge identification is to create a line drawing of the subset image. The extracted features are then utilized by computer vision calculations. An established technique for edge recognition includes the utilization of tool operators, a two dimensional channel. An edge in an image happens when the change in x and y is most distinct. The technique works by distinguishing these substantial gradients to recognize the edges. There is a huge measure of operators intended to recognize certain sorts of edges. The operator can be arranged to scan for vertical, level, or corner to corner edges. One noteworthy issue with edge discovery is when commotion is available in images. It isn't sufficient to just diminish the clamor, on the grounds that the picture will be either twisted

or obscured. Fortunately, the operator has sufficiently normal information to rebate confined uproarious pixels. In any case, the adjustment in force is not generally a stage change. The power change can likewise be slow where the operator at that point must be altered for reliable edge detection. Therefore, there are issues of missing genuine edges, false edge location, and high computational time. (Kim, 2013).

2.5.6 Gaussian Filter

Gaussian filter is utilized to obscure and get rid of undesirable detail and noise. By computing a 5 X 5 mask, the Gaussian smoothing can be performed utilizing standard convolution strategy. A convolution veil is substantially littler than the real picture. Therefore, the mask is slid over the image, ascertaining each square of pixels at once. Gaussian utilizes 2D appropriation to perform convolution. The bigger the width of the Gaussian cover, the lower is the identifier's affectability to noise. The heaviness of the framework is amassed at the inside, subsequently any noise showing up in the outside segments and columns will be disposed of, as the weight diminishes outward from the middle esteem. The restriction mistake in the identified edges additionally increments marginally as the Gaussian width is expanded. The expanding of standard deviation decreases hazy spots the power of the commotion. (Irfanullah, Azeezullah, no date).

2.5.7 Piecewise Parabola Extraction

The strategy depends on a brief road geometric portrayal alongside a deformable layout coordinating technique (Hu, Zhang and Tao, 2004). All the more imperatively, the strategy can be flawlessly incorporated into a commonsense digitizing process. The piecewise parabola display is developed by seed focuses coarsely put by a human administrator. Road extraction really turns into a physical issue of comprehending of each bit of parabola with just a few obscure parameters by utilizing image requirements in this manner the method utilizes a minimum square layout coordinating to understand the parabola parameters. The format is deformable created in view of the programmed recognition of parallel edges. Broad testing investigates different image sets exhibit that the technique can extricate road centerlines dependably. It offers substantially higher effectiveness rather than manual digitizing process.

2.5.8 The Roberts Detection

The Roberts Cross operator plays out a basic, fast to process, 2-D spatial angle estimation on an image. Pixel at each point it yields the assessed output of the spatial slope of the information on

the image by then. The technique is comprised of a 2×2 convolution part. These parts are intended to act accordingly maximally to edges running at 45° to the pixel network, one portion for every one of the two opposite orientations. The orientations can be connected freely to the input image to create isolate estimations of the inclination segment in every orientation. (Singh et al., 2013).

2.5.9 The Prewitt Detection

The Prewitt edge identifier is a proper method to assess the size and orientation of an edge. The Prewitt operator is constrained to 8 conceivable angle arrangements, though most direct orientation gauges are very less more exact. This angle based edge indicator is assessed in the 3x3 neighborhood for 8 bearings. All the eight convolution masks are figured. The convolution cover with the biggest module is then chosen (Context et al., 2016).

2.6.0 Canny Edge Detector

The Canny edge identifier is broadly utilized as a part of computer vision to find sharp power changes and to find object limits in an image. The Canny edge locator groups a pixel as an edge if the slope size of the pixel is bigger than those of pixels at the two its sides toward greatest intensity change. Characterizing edges in this way makes some conspicuous edges be missed. There is have to amend the Canny edge locator to enhance its identification precision (Lijun Ding, Ardeshir Goshtasby, 2000).

It is a technique to ascertain edges by segregating clamor from the image without influencing the features of the edges in the image and afterward applying the propensity to recognize the edges and the basic incentive for edge. The Canny edge locator smoothies the image to dispose of unnecessary noise. At that point it finds the image slope to feature districts with high spatial subordinates. After that it performs following along these regions and stifles any pixel that is not at the most extreme. The inclination exhibit as of now can additionally be decreased by hysteresis which is utilized to track along the rest of the pixels that have not been stifled. Hysteresis utilizes two edges and if the extent is less than the main limit, it is set to be an edge. In the event that the extent is over the high limit, it is made an edge (Saluja, Singh, Agrawal, 2013).

2.7 OOIA feature extraction associated works

Hu, Zhang and Tao (2004) have displayed a programmed road centerline extraction from very high resolution satellite imagery. They have proposed a progressive gathering technique to automatically extricate fundamental road centerlines from high-determination satellite symbolism. Progressive gathering here has implied that as opposed to gathering all portions without a moment's delay, specific fragments are assembled bit by bit, and various signs are firmly coordinated into the technique. Through the stepwise gathering, the recognized divided line fragments have in the end shaped the long primary road lines. Gomes, Feitosa and Coutinho (2004) proposed another technique to distinguish sub-pixel unpaved roads. The technique tries to copy the human capacity to identify such road notwithstanding all designated viewpoints, via scanning for long, thin and smooth line portions whose ghastly reaction are nearer to the uncovered soil than the encompassing pixels. The technique execution is assessed on fragments of Landsat scenes (groups 3, 4 and 5) of the Alcinópolis County, situated in the State of South Mato Grosso in Brazil. There is much accentuation that finding unpaved roads in low-determination satellite images is anything but a paltry undertaking. Tests on LANDSAT images from the Midwest Brazil have demonstrated that the technique is a significant guide to enhance the output of the image analysis assignment to the extent the detection of unpaved roads is concerned.

Nobrega and Hara (2012) put forward a thesis which applied technology on road detection and classification in informal settlements areas. An 11 bit Ikonos multi-spectral image was utilized. Essential parts were pre-figured and utilized on features customization. Auxiliary information were computed from spectral data and joined with geometric data of the portions. Arrangement rules were made from objects data, by utilizing blend between unique multispectral bands, important segments and additionally utilizing mixes of geometric attributes like width, length, neighbor and asymmetry and logical ones. Considering the Ikonos second foremost part as a brilliant marker of impenetrable areas, and considering the recognition of uncovered soil territories, cleared and unpaved roads were segregated. Preparatory outcomes have shown that this classification technique produces precise outcomes. Examinations between automatic methodologies and manual ones authenticated the effectiveness of the technique. To assess the precision achieved, an examination between these two classifications of road street polygons was executed. The general precision was 65%. However, object based methodologies have achieved

more exact outcome, it has been kept in mind that that the roads in informal settlements are unpredictable, thin and contain diverse asphalts and texture.

Technology (2016) presented a technique for extraction of unpaved roads from high resolution satellite images. Sandy area candidates were acquired through thresh-holding of significant shading space segments from HSV and YCbCr. Legitimate mix of these applicants was performed to give the sandy locale. Morphological technique (Dilation) was utilized to refine the sandy area, while Hough transformation was utilized to extricate road segment from the entire sandy district. The created calculation was executed in MatLab and tried with tests of satellite images procured from Google Earth Map. Subjective (visual quality assessment) and target parameters (Gap Statistics) were utilized for execution assessment. The outcome demonstrates that the new calculation effectively separates unpaved roads from satellite imagery the created calculation performed brilliantly for straight unpaved roads (100%), while it performed sufficiently well (91%) for an image with a interlinked of unpaved roads.

In a research done by Bacher and Mayer (2003) they connected a programmed approach for road extraction from pan sharpened IKONOS images which makes utilization of the 1m view mode and the multispectral data. The approach comprises of three principle steps and can be viewed as an extra to the approach of Wiedemann (2001) .In the initial step, preparing zones for a multispectral classification are extricated in all channels utilizing the Steger differential geometric line administrator. Moreover, there must be parallel edges with a homogeneous territory between them inside an area of the extricated lines. In the second step, the preparation territories are utilized for a fluffy multispectral arrangement. With it, extra road pixels are extricated. The quantity of misclassifications is limited by methods for a rank filtering. In the last task, holes in the preparatory road network produced with the approach of Wiedemann (2001) are shut by methods for zip-lock line utilizing that comes about.

CHAPTER THREE

Methodology

3.0 Introduction

This chapter covers the overall procedure carried out in achieving the set out objectives of the research. The research methodology will give an in depth overview of the data acquired, the methods and approaches used to come up with the results. An analysis of the techniques employed in the research indicating strengths and weaknesses of each will be shown in this chapter.

3.1 Research Design

Feature extraction is the consolidated procedure of fragmenting an image into regions of pixels, computing attributes for every region to make questions, and ordering the objects (with rule based or supervised classification) based on characteristics, to delineate features. In this research, rule based classification was utilized to extract unpaved roads. The overall workflow is summarized in Figure 1.
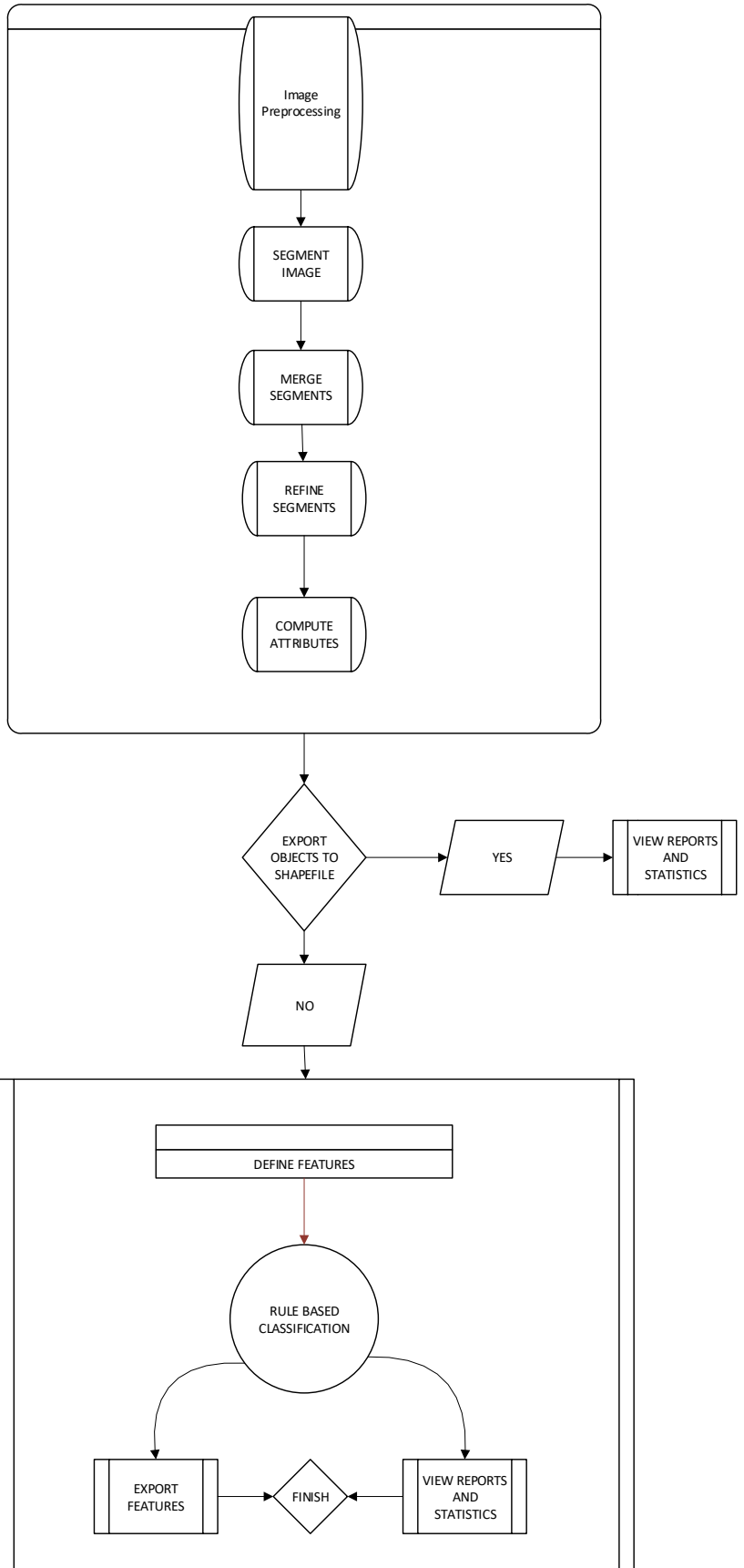
.

Fig 1

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3.2.0 Finding Objects

The Find Objects undertaking is partitioned into four stages: Segment, Merge, Refine, and Compute Attributes. When you finish this assignment, you will carry out the Extract Features undertaking, which comprises of rule based classification and exporting results to shape files as well as raster images.

3.2.1 Segment Image criteria

Segmentation is the way toward dividing an image into objects by gathering neighboring pixels with same qualities. The objects in the image ideally correspond to real-world features. Powerful segmentation guarantees that segmentation comes about more precise. ENVI EX utilizes an edge-based segmentation calculation that is quick and just requires one information parameter (Scale Level). By stifling frail edges to various levels, the calculation can yield multi-scale division comes about because of better to coarser division. The division calculation computes an inclination delineate the picture; it ascertains a thickness work for the angle outline; figures an altered slope outline the first slope outline, capacity, and Scale Level; at that point it portions the adjusted inclination delineate.

3.2.2 Merge Segments

Merging is a discretionary advance used to aggregate small sections inside bigger, finished zones, for example, trees, mists, or fields, where over-segmentation might be an issue. Merging consolidates contiguous segments with similar spectral qualities. The Merge Level parameter represents the limit lambda, which ranges from 0.0 to 100.0.Through an expanding nonlinear mapping, the parameter is more controllable and appropriate for see. ENVI EX utilizes the Full Lambda-Schedule calculation. The calculation iteratively consolidates contiguous segments in view of spectral and spatial data. Merging continues if the calculation finds a couple of neighboring regions, I and j, with the end goal that the consolidating cost is not as much as a characterized edge lambda value:

$$t_{i,j} = \frac{\frac{|O_i| \cdot |O_j|}{|O_i| + |O_j|} \cdot \|u_i - u_j\|^2}{\text{length}(\partial(O_i, O_j))}$$

Equation 1

3.2.3 Refining Segments criteria

Another discretionary combining strategy called thresh-holding is utilized at this phase of finding objects. It is helpful for extracting point features when over segmentation is an issue. Thresh-holding is a raster task that works with one band of Region Means picture to gather nearby fragments in on their brightness value (advanced number or DN). Thresh-holding functions admirably with features that are in high contrast to their background.

3.2.4 Computing Attributes

Feature Extraction utilizes an object based way to deal with classification, rather than pixel-based order. The advantage of an object based approach is that items can be portrayed with an assortment of spatial, spectral, and texture characteristics. In the Compute Attributes step, ascribes were characterized to register the object to be extracted. For the proposed work, spatial, spectral and texture attributes were all applied. ENVI EX comprises of 14 attributes (Area, Length, Compactness, Elongation, Convexity, Solidity, Roundness, Formfactor, Rect_fit, MainDir, Numholes, Holesolrat, Minaxislen and Maxaxislen) and spatial. The spatial attributes that were defined and computed were Elongation, Compactness, Length and Area. Formulas for calculating Compact, Convexity, Solidity, Roundness, and Formfactor are from Russ (2002). ENVI EX calculates all of the spatial attributes based on a smoothed version of the geometry, not the original geometry (Douglas and Peuker, 1973). Performing calculations on a smoothed geometry ensures the shape measurements are less sensitive to object rotation.

Elongation: A shape measure that shows the proportion of the real hub of the polygon to the minor pivot of the polygon. The major and minor tomahawks are gotten from an arranged bounding box containing the polygon. The extension esteem for a square is 1.0, and the incentive for a square shape is more noteworthy than 1.0.

ELONGATION = *Maxaxislen / Minaxislen*   **Equation 2**

Compact: shows the conservativeness of the polygon. A circle is the most minimal shape with an estimation of 1 / pi. The compactness value of a square is *1 / 2(sqrt(pi)).*

COMPACT = *Sqrt (4 * AREA / pi) / outer contour length* **Equation 3**

Length: The combined length of all boundaries of the polygon, including the boundaries of the holes. This is different than the maxaxislen attribute. Values are in map units.

Area: Total area of the polygon, minus the area of the holes. Values are in map units.

Spectral attributes available in ENVI EX are Minband_x, Maxband_x, Avgband_x, Stdband_x. The four attributes are computed for each band x in the original image. The shape file attributes have 4 * x entries comprising the spectral attributes. The spectral attribute that was defined and computed is the Avgband_4 and this depended on the 4 bands of the original image.

Avgband_4: Average value of the pixels comprising the region in band x.

3.2.5 Extraction of features

The Extraction Features task is divided into 3 steps: Rule Based classification, Export features and viewing of reports and statistics.

3.2.6 Rule Based Classification

Rule-based classification is grouping is a propelled method that gives you a chance to characterize by building rules in view of object attributes. Rule based classification is an intense tool for feature extraction, frequently performing superior to supervised classification. Rule-building is primarily based on human knowledge and reasoning about specific feature types. Building new rules involves various classes. Each class will contain at least one rule (which contain a variety of different attributes) that best describe the class. For instance, when extracting roads from an image, you could fabricate a rule set that will utilize a mix of Elongation, Length, and Area spatial attributes:
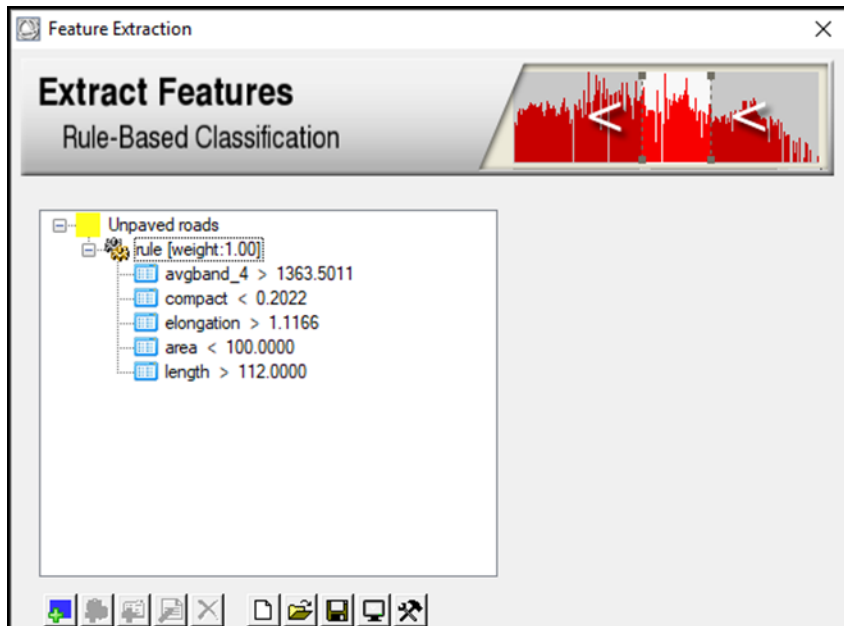
Figure 2

To meet the conditions of the Roads class, either one of the two rules must apply (i.e., the OR operation). The first rule has only one attribute definition. To satisfy the conditions of the second rule, both the Length and Area attribute definitions must apply (i.e., the AND operator). Each rule is equally weighted, which works well in most cases.

3.2.7 Export Classification Results

In this progression, there is determination of sorts of images, vectors, and statistical reports to different configurations. As a matter of course in ENVI EX, documents are spared to the index that is indicated in the Output Directory. At the point when the export is finished, the component extraction work process ends.

3.2.8 Accuracy Assessment

According to Bogoliubova (2014), image classification cannot be considered complete until we obtain an estimate of its accuracy. The translator (decoder) needs to decide precisely how the object classes in the image relate to these classes on the earth (landscape) surface. In the investigation of image handling the expression "precision" implies a measure of consistency with dependable data in a spatial point with information on the classified image (Jensen 1996).

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The results of precision evaluation are typically abridged in a perplexity lattice, which portrays the classification error for each class, as well as errors identified with incorrect classification. This contingency table is regularly alluded to as a confusion matrix, misclassification matrix (Bogoliubova, 2012), or error matrix. The error matrix is composed of an equal number of rows and columns (a square matrix of n×n dimension), where n – the number of object classes on a control map or ground referencing information.

A confusion framework, otherwise called an error matrix, is a particular table format that permits representation of the execution of a calculation, ordinarily a supervised learning one (in unsupervised learning it is normally called a matching grid). Each row of the framework represents the cases in an anticipated class while every column represents the cases in an actual class (or the other way around. In predictive analysis, a table of confusion (once in a while additionally called a confusion matrix), is a table with two lines and two segments that reports the quantity of false positives, false negatives, true positives, and true negatives. The figure below shows the structure and contents of a confusion matrix.

		True condition	
	Total population	Condition positive	Condition negative
Predicted condition	Predicted condition positive	True positive, Power	False positive, Type I error
	Predicted condition negative	False negative, Type II error	True negative

Figure 3: Source David M W (2011).

Definition of conditions (Validation Matrix)

A genuine positive **(TP)** test result is one that distinguishes the condition when the condition is available

A genuine negative **(TN)** test result is one that does not detect the condition when the condition is not available.

A false positive **(FP)** test result is one that identifies the condition when the condition is missing.

A false negative **(FN)** test result is one that does not detect the condition when the condition is available.

These metrics are then used to calculate Sensitivity, Specificity and Accuracy as:

Sensitivity measures the ability of a test to detect the condition when the condition is present. Thus, *Sensitivity = TP/ (TP+FN).*

Specificity measures the capacity of a test to accurately reject the condition (not identify the condition) when the condition is missing. Thus, *Specificity = TN/ (TN+FP).*

Predictive value positive is the extent of positives that compare to the nearness of the condition. Thus, *Predictive value positive = TP/ (TP+FP).*

Predictive value negative is the proportion of negatives that correspond to the absence of the condition. Thus, *Predictive value negative = TN/ (TN+FN).*

Accuracy: *(TP+TN)/ (TP+FP+TN+FN)*

3.2.9 Methods and material used

In determining the validation metrics, 25 points were randomly selected on identified unpaved roads and a comparison was undertaken using the original subset image. Actual classes and classes that the OOIA algorithm extracted were enumerated both on the original image and processed vector output thus ascertaining the number of true positives (TP), false positives (FP), true negatives (TN) and false negatives (FN). The classes that were predicted or rather confused

by the algorithm were rooftops and pathways near houses. After a thorough rundown of the validation metrics, Sensitivity, Specificity and Accuracy were deduced.

3.3.0 Chapter summary

The overall procedure and methods employed in this study have been mentioned in this chapter. Each of the methods employed produced a specific result meant at achieving the set out objectives. The key to producing results was in the proper procedural execution and linking of methods used.

CHAPTER FOUR

Results and Analysis

4.0 Introduction

This chapter gives the results obtained from carrying out the procedures stated in the methodology section (see Chapter 3).

4.1 Pre-processing results

All the bands of Plaedis satellite imagery were loaded and stacked in ENVI 4.7. Stacking involves loading a series of images of different bands into one composite file.
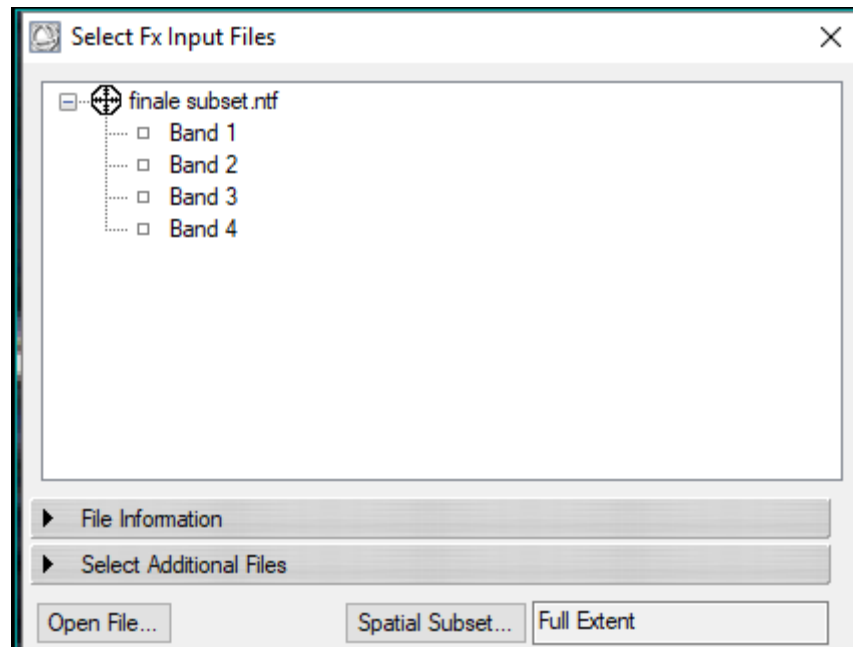

Figure 4 shows the stacking of all the bands of Plaedis image.

4.1.1 Study area-region of interest (ROI)

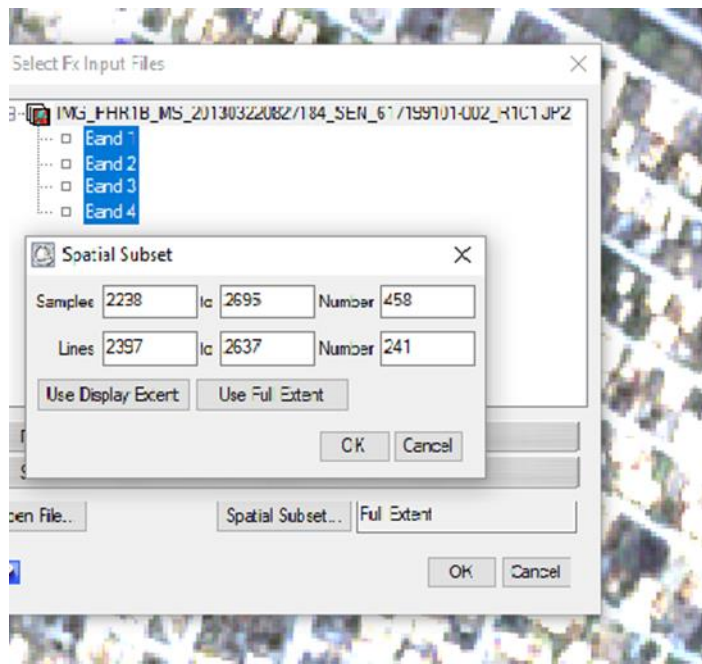The region of interest (ROI) was defined using the spatial subset tool in ENVI 4.7.

Figure 5 Shows the spatial subset extents of ROI.

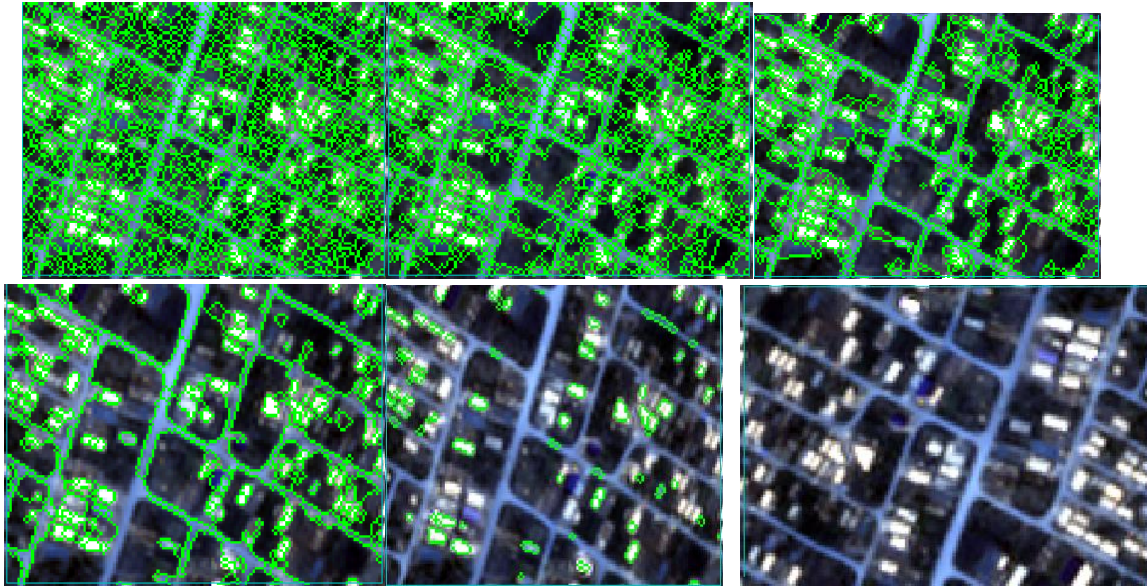## 4.1.2 Results of segmentation effects

Figure 6. Comparison of different segmentation effects under different scales (0, 20, 40, 60, 80 and 100 respectively).

Choosing a high Scale Level causes fewer segments to be defined, and choosing a low Scale Level causes more segments to be defined. Highest Scale Level delineates the boundaries of features as well as possible. Good segmentation ensures that classification results are more accurate. Choosing too high of a Scale Level, the boundaries between segments will not be properly delineated and feature of interest is lost. It was found out that scale level *60* was the most suitable and optimum for unpaved roads.

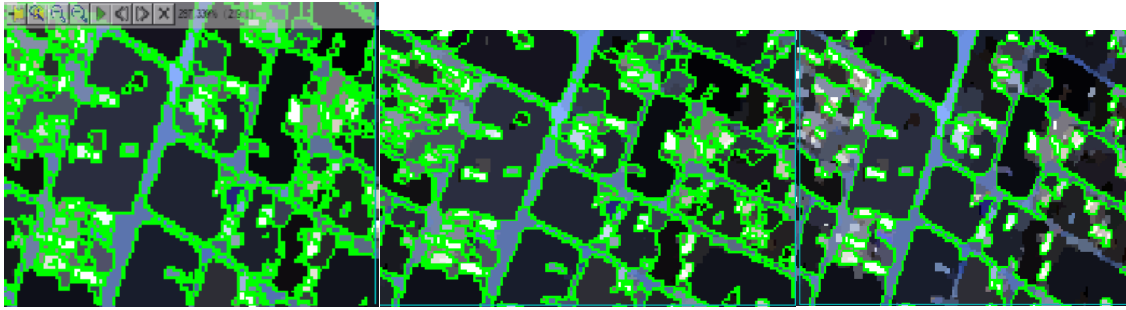## 4.1.3 Results of merging segments criteria

Figure 7 Comparison of different merging segments effects under different merging levels (20, 60 and 90 respectively). Merging level *90* was found to be the optimum merging level.

4.1.4 Results of computed attributes and rule based classification.

At refinement stage, no thresh holding was applied.

Attributes Computed:

  Spatial (elongation > 1.1166, compact < 0.2022, Length >112.000, Area<100.000)

  Spectral (avgband_4 > 1363.5011)

Classification: Rule-Based

Rule Set:

#1 (1.000): If avgband_4 > 1363.5011 AND compact < 0.2022 AND elongation > 1.1166 AND Length >112.000 AND Area >112.000, then object belongs to "Unpaved roads".
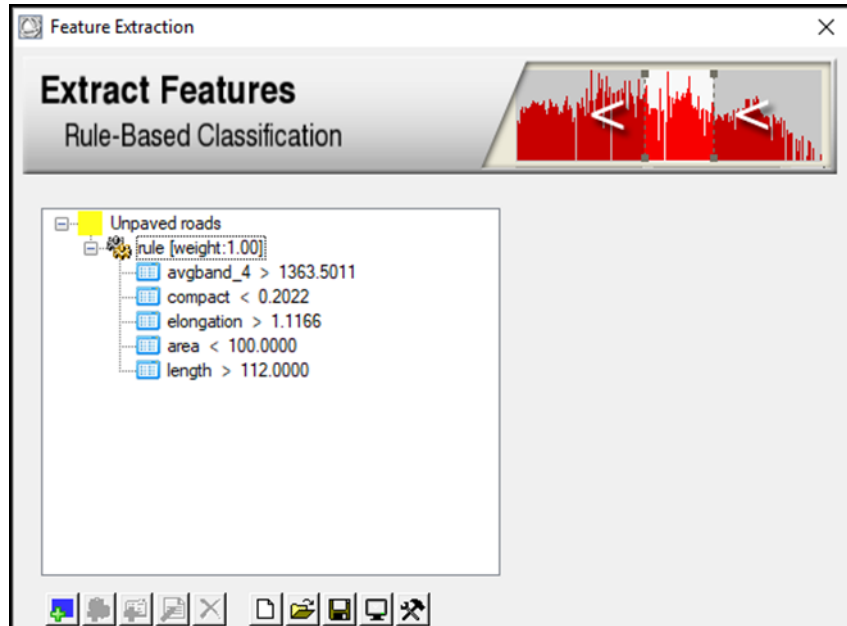
Figure 8 Output of the rule based classification and the rule sets executed.

4.1.5 Results showing the extracted unpaved roads in various formats.
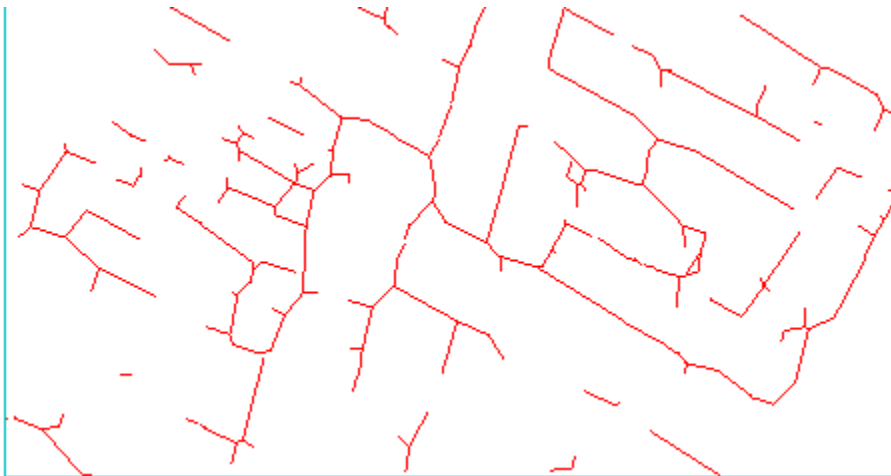

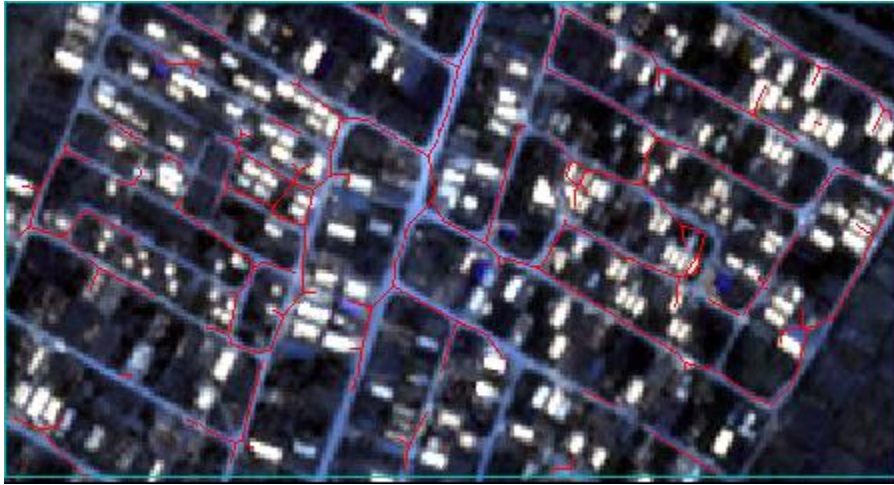**Figure 9** Extracted Unpaved roads in vector line format.

Figure 10. Overlay of line vector format of unpaved roads and the original multispectral subset image.
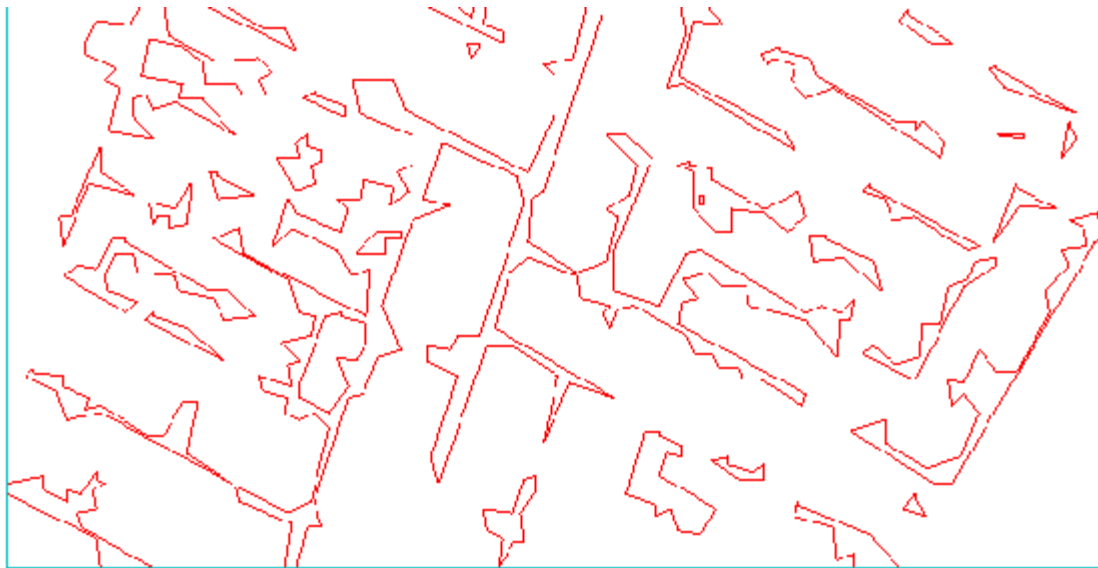

Figure 11 Vector polygon format of extracted unpaved roads.

Figure 12 Vector line format of extracted unpaved roads from a panchromatic image.

Figure 13 Overlay of line vector format of unpaved roads and the original subset image of a panchromatic image.

4.1.6 Accuracy Assessment results

Confusion matrix showing Actual and Predicted classes by the OOIA algorithm:

		Actual Class		
		Unpaved Road	*Pathway*	*Rooftop*
Predicted Class	**Unpaved Road**	29	1	0
	Pathway	2	12	14
	Rooftop	0	0	0

Table 1

Corresponding table of confusion, for the unpaved roads class:

		Actual Class		
Predicted Class		*Unpaved Roads*	*No-Unpaved Roads*	
	Unpaved Roads	29 True Positives	1 False positive	
	Non-Unpaved roads	2 False Negatives	26 True Negatives	

Table 2

Sensitivity = TP/ (TP+FN) = 55/58*100= 94.82%

Specificity = TN/ (TN+FP) = 26/27*100 = 96%

Accuracy = (TP+TN)/ (TP+FP+TN+FN) = 94.82%

Deductions

The ability of OOIA automatic feature extraction to correctly exclude similar features to unpaved roads when the condition of unpaved roads is absent is 96%.

The ability of OOIA automatic feature extraction to correctly detect unpaved roads when the condition of unpaved roads is present is 94%.

The overall accuracy of OOIA feature extraction proposed method to differentiate mixed features with similar characteristics is 95%.

CHAPTER FIVE

5.0 Introduction

This chapter analyzes the results of the research, giving conclusion as to the findings of the research, the limitations to the research and recommendations for improvement of this research.

5.1 Evaluation

Results show that the sensitivity, specificity, and accuracy of the OOIA method used could reach approximately 93%, 96% and 95% respectively, indicating that the proposed method is effective for unpaved roads extraction.

5.1.1 Objective I

A rule based classification was achieved using optimum threshold values for spatial, spectral and textural attributes. A rule set involving area, length, elongation and average band of unpaved roads was executed making it possible to delineate unpaved roads from the satellite image.

5.1.2 Objective II

The segmentation process turned out to be a challenging task due to the similar spectral characteristics of other features such as bare soil and clay roof tops with unpaved roads. Merging made it possible to further refine the segmented objects.

5.1.3 Objective III

The performance of the OOIA feature extraction was validated successfully using a confusion matrix. It did not only describe the classification error for each class but also errors related to incorrect classification. The ability of the algorithm proved to be effective when it comes to extraction of unpaved roads. Specificity, sensitivity and accuracy of the OOIA algorithm ascertained were very convincing.

5.2 Conclusion and Recommendations

The results of this project indicate that high resolution data can be reliably and rapidly used to update road maps at both national and regional levels particularly unpaved roads. However, it should be noted that use of different types of imagery such as multispectral and panchromatic varies remarkably. Multispectral imagery experienced rigorous rule sets due to the fact of several

bands whereas panchromatic imagery possesses lesser bands that require a few set of rule sets algorithms. This suggests that object-oriented classification has great potential for extracting unpaved roads from satellite imagery. To improve the accuracy of the object-oriented classification, further work refining the process is continuing. The use of multi-sensor data and ancillary data, such as DEM data sets and GIS layers, is being investigated. Also development of a filtering technique that can successfully differentiate unwanted patches from extracted unpaved roads in the results can also be included in the future works.

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