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A Review on Shoreline Detection Framework Using Remote Sensing Satellite Image

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***Abstract*— Shoreline is usually defined as the intersection of the land with the water surface of the mean high water line with the beach profile. In relation, most research in recent years has set the focus on remote sensing which makes it possible to collect data on this shoreline areas. Furthermore, shoreline detection is the ability to recognise and evaluate shoreline detection, so that facilitates decision makers to adapt, mitigate and manage the shoreline risks. Thus, this paper aims to investigate current works on shoreline detection framework using remote sensing satellite images. This investigation includes current research trends on the computational method in shoreline detection, image segmentation, and image filtering method.**

Keywords — remote sensing satellite image, shoreline characteristic, and shoreline detection framework.

I. Introduction

The shoreline delineation is difficult, time-consuming, and sometimes impossible for the entire coastal system when using traditional ground survey techniques [1]. Consequently, remote sensing satellite images overcomes the difficulties in the extraction of shoreline. Many computational methods have remained to be improved, and comprehensive methodologies are needed to be developed to extract the complex properties of multi-features in remotely sensed imagery. Delineating shoreline for environmental conservation with remote sensing assessment is important for shoreline management and mangrove conservation purpose. Dramatic changes in delineating shoreline have become vital which affected the mangrove forest. Thus, the current methods for shoreline detection are categorised into two: image enhancement and image filtering. Based on a present study, high accuracy of shoreline detection can be done cost-effectively by using medium resolution images. Therefore, this study aims to identify current works on shoreline detection that utilising remote sensing satellite images. This paper is composed of several sections. Section II explains on the remote sensing satellites images. Section III discusses the shoreline characteristics. Then, in Section IV, the image enhancement method used to resolve the image problems are discussed. Next, Section V discusses on image filtering method to resolve image issues and preserve the edge on the satellite images. The shoreline detection framework is explained in Section VI, and the conclusion and recommendations for future work are presented in section VII.

II. Remote Sensing Satellites Images

Most research in recent years has set the focus on remote sensing which makes it possible to collect data on dangerous and unreachable areas. There are numerous remote sensing applications in the field of meteorology, oceanography, geology, agricultural, forestry, and sea studies. Remote sensing is a scanning process of the earth from the distance of a satellite or high flying aircraft to acquire information on the areas of interest. The information is recorded, processed, analysed and applied. Generally, the remote sensing device is registered based on the magnitude and frequency energy from electromagnetic energy. There are many in-depth and richer information revealed by detecting waveforms from beyond the rainbow of either visible light, or the invisible one. As depicted in Fig. 1, it has been shown that the electromagnetic spectrum describes the systems that classify, according to wavelength, all energy that moves at the constant velocity of light [2].

The sensor senses an energy that reflected from the earth. Both sensors can be on the satellite or mounted on the aircraft. The remote sensors can divide into two. Remote sensor can be either active or passive. Active sensors use their energy source for illumination. In contrast, passive sensors sense sunlight radiation reflected from the earth. For an example of usage of the active sensor are an optical sensor, radar, and LIDAR while for the passive sensor are LANDSAT, SPOT, and ASTER. There are pros and cons for an active sensor which an active sensor can penetrate clouds, light rain, and snow. However, it can be influenced by other radiation sources.

The resolution of sensors split into three categories; spatial resolution, spectral resolution, and radiometric resolution. Each resolution has its characteristics. For example in spatial resolution, it describes the ability of a sensor to define the more exceptional wavelength intervals where, the higher the spectral resolution, the better the quality of the wavelength range for specific channels. Meanwhile, satellite sensor stores information about objects in the form of a grid. A pixel is the smallest area unit in a digital image. However, the resolution of an image is determined based on the size of the pixel. Therefore, the higher resolution and the finer grids, make the details more recognisable on the ground's surface. The resolution can be categorised into three ranges, from few centimetres to kilometres which are:

i) Low resolution: Higher than 30 meters.
ii) Medium resolution: 2 – 30 meter.
iii) High resolution: Below 2 meter.

Spectral resolution records energy over several wavelength ranges where this is referred to a multi-spectral image while the advanced multi-spectral image is referred to the hyperspectral image. In the hyperspectral image, it detects hundreds of extremely narrow spectral channels. Therefore, the hyperspectral image gives more advantages over multispectral images which dramatically increases the number of channels available for image classification application. Thus, these channels need a precise understanding of the purpose of ground materials that need to be measured in image classification application. However, due to environmental condition and natural variation in materials, the image classification process in hyperspectral imagery becomes difficult by having a broader data set which requires new processing method and has not managed to be developed as in multispectral imaging. Consequently, multispectral image attracts significant attention to the researcher to explore and make it as a valuable tool to remote sensing. These conclude that multispectral image is commercially used in crop identification, shoreline detection, coastal zone environmental planning and hazard management as shown in Table 1 [3],[4],[5].

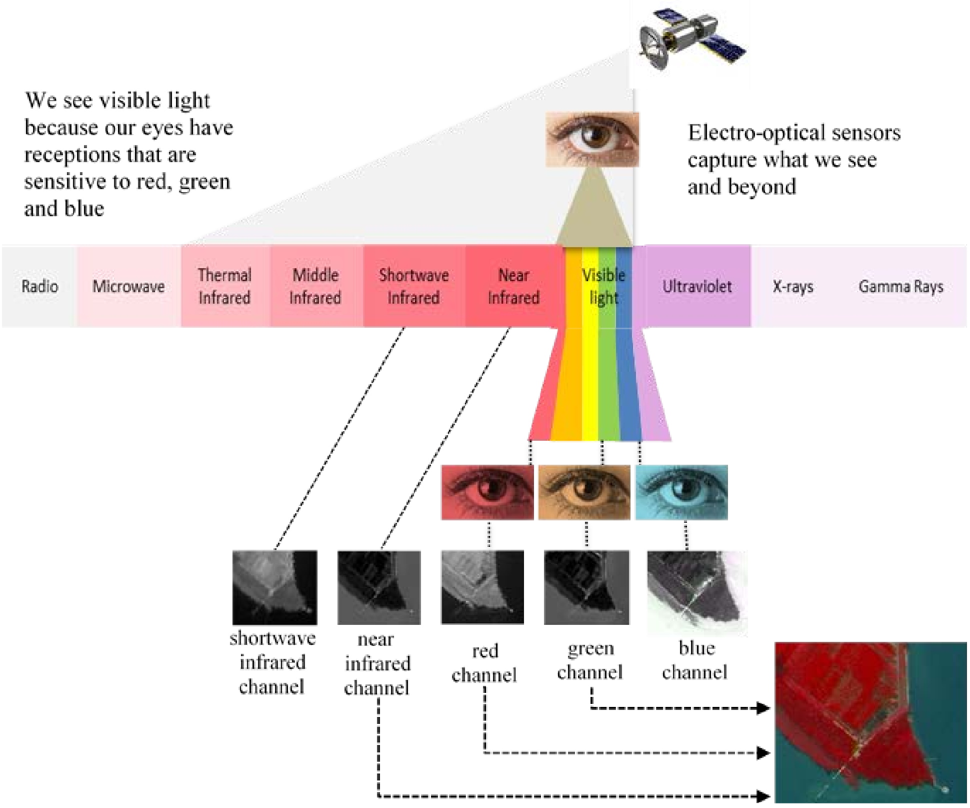
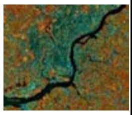
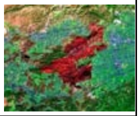


Fig. 1. The electromagnetic spectrum

A multispectral image is an image that contains more than one spectral channel captured within a specific wavelength, ranges across the electromagnetic spectrum. A colour image is a straightforward example of a multispectral image that contains three channels. The multispectral images have different spectral properties of the material on the earth surface. The standard spectral properties like near infrared (NIR), are utilised in the detection of healthy vegetation. Therefore, the combination of visible and NIR channel can be used to detect the health condition of vegetation. The detection process is done by utilising one or more vegetation indices such as the Normalized Difference Vegetation Index (NDVI) where the ratio of the difference of the red and NIR channel is divided by the total of these two values. In contrast, panchromatic images consist of one band of reflectance data with higher spatial resolution than the multispectral images where the single channel image is displayed in grayscale effect.

Table 1: Comparison of multispectral images.

Data	**RapidEye**	**SPOT-5**	**Landsat**	**ASTER**
				
Resolution	5m	2.5m/5m/10m	30m	15 to 90 m
Features	Can detect smaller areas of change	Better identification of smaller feature	More spectral channels than SPOT imagery and produce larger image	Can detect land cover change and the generation of digital elevation models (DEM)
Vegetation	Contain red edge channel for chlorophyll detection, suits for vegetation monitoring	The spectral channel in the shortwave infrared channel is important for vegetation data	Useful to create map for vegetation cover	Useful for vegetation, ecosystem dynamics, geology, and soil studies
Availability	Buy	Available for use in this study by the Malaysian Remote Sensing Agency	Free access from USGS website	Not available for use in this study by the Malaysian Remote Sensing Agency

For instance, Landsat satellite was sent into orbit in 1972 which was the first multispectral imagery available commercially. Several sensors were sent into space with varying spatial and spectral resolutions including the SPOT satellite. In Table 1, the comparison of multispectral images is shown. Among the four satellite images, SPOT images provide multispectral and panchromatic modes. Meanwhile, Table 2 shows the uses of each channel in the SPOT-5 image. Basically, SPOT-5 images are selected in this study because of the resolution range (3 meter – 5 meters) and have been set as available by the Malaysian Remote Sensing Agency. SPOT image is an affordable source of information for monitoring, analysing and managing resources on earth which include geographic information systems, agricultural, environmental protection and coastal monitoring [6],[7],[8],[9].

The SPOT-5 program consists of a series of French optical remote sensing satellites launched in 2002. The program provides panchromatic and multispectral images. The panchromatic images consisted of only one channel and displayed in grayscale of 5m resolution. The multispectral images include red, green, NIR and shortwave infrared (SWIR) channels of 10m resolution. The lack of blue channel in both the multispectral and panchromatic images is not a problem in the detection of vegetation or water bodies. The NIR channel plays an important role in image contrast of vegetated areas due to the high reflectance of leaves in the NIR wavelength region [10]. Furthermore, several shades of grey can be recognised in the vegetated areas, matched to different types of vegetation, and water mass will appear dark in the NIR channel [10]

Pan-sharpening is a process of merging a high-resolution panchromatic data with medium resolution multispectral data to create high-resolution multispectral images [11] There are a few pan-sharpening methods used, as shown in Table 3. Each of these methods uses a different model to improve the spatial resolution to maintain the colour, and some are enhanced to include the weighting where a fourth channel can be included. Therefore, by adding the weighting and enabling the infrared component, the visual quality in the output colours is improved.

Table 2: Uses of channel in SPOT-5 image

Mode	**Channel**	**Micrometers**	**Uses**
Multispectral	Green	0.50-0.59 micrometers	Recommended for use in combination with another channel because of low contrast and sensitivity to haze
	Red	0.61 – 0.68 micrometres	Best for showing roads and bare soil. This channel heightens the contrast between vegetated and non-vegetated areas
	NIR	0.78- 0.89 micrometers	This channel is used to evaluate vegetation biomass and separate water from vegetation.
	SWIR	1.58 – 1.75 micrometres	A single channel spectral mode of acquisition provides only black and white images
Panchromatic	-	0.51- 0.73 micrometers	This channel is intended primarily for applications calling for fine geometrical details

Table 3: Pan-sharpening method

Method	Reference	Description
Brovey transformation	[12],[13]	• Increases the contrast effect in the low and high ends of the data image histogram.
HIS	[11],[14]	• Converts the multispectral image from RGB to intensity, hue, and saturation • Produces high spatial resolution multispectral images but with colour distortion, especially in vegetation areas.
Esri	[15]	• Uses a weighted average and the additional NIR channel (optional) to create its pan-sharpened output channels. • The result of the weighted average is used to create an adjustment value (ADJ) that will then be used in calculating the output values.
Simple mean	[15]	• Uses a simple mean averaging equation for each of the output channel combinations.

Moreover, many colours can be generated by combining the three primary colours (red, green, blue) in various proportions. The results of three colours are combined, which will eventually produce a different colour invisible spectrum. The colour composite images can be classified into two categories which are true colour composite and false colour composite. For true colour, the composite consists of three visual primary colour bands (red, green, blue) in the multispectral images. In contrast, the false colour composite image does not have any resemblance to its actual colour. Some colour combinations are suitable for detecting specific features in the images as depicted in Table 4 [16].

Table 4: Common false color channel combination

Color combination	Description
R = NIR G = Red B = Green	• Allows vegetation to be detected • Vegetation appears in different shades of red depending on the types and condition of the vegetation since it has high reflectance in the NIR band
R = SWIR G = NIR B = Green	• Used to show floods or newly burned land
R = Blue G = SWIR B = SWIR	• Used to differentiate between snow, ice, and clouds

III. SHORELINE CHARACTERISTICS

The shoreline is defined as the intersection of the land with the water surface of the mean high water line with the beach profile as illustrated in Figure 2. The shoreline detection is the ability to recognise and evaluate shoreline detection and to efficiently communicate potential future scenarios with decision makers are thus important for adaptation to, and mitigation of increasing shoreline risks and development of forward-looking plans for shoreline resource management [17]. Hence, the awareness of shoreline position is the source for overcoming shoreline problems, measurement of the shoreline and characterising land water resources [5]. In addition, multispectral satellite image provides several spectral channels, including the NIR. NIR channel is important in vegetation identification where the reflectance is much higher due to the presence of chlorophyll in the leaves. On the other hand, these channels are utilized in the land-water interface. For example, by using Channel Rationing Method in Landsat MSS, TM and ETM+ exhibit a high reflectance of mid-infrared by vegetation and natural features [18]. Consequently, the remotely sensed imagery is widely used to investigate and monitor environmental changes which include the study of features extraction. These studies make it essential for most urban planning applications such as in the shoreline and vegetation extraction. There is a broad range of feature extraction methods used for detecting different criteria of feature signatures.

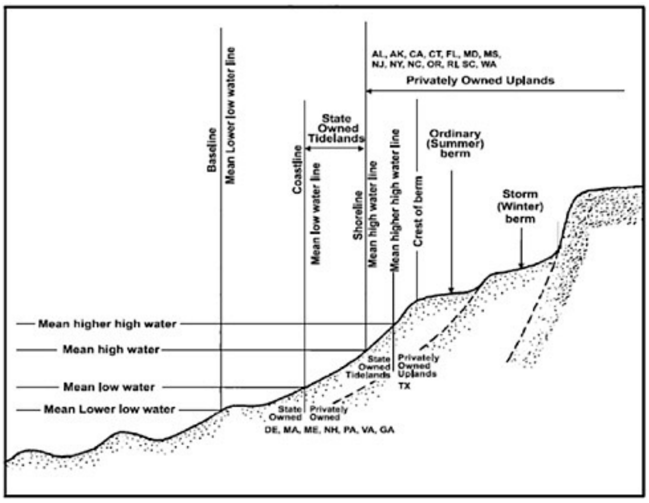


Fig.2 Definition of shoreline (National Research Council, 2007

Shoreline movement is a complex phenomenon occurred as the result of both natural and anthropogenic effects [19]. For countries like Malaysia, the significant shoreline extension makes the nautical chart products one of the most useful sources of information either in navigational, military, planning and coastal management purposes [20]. Furthermore, the data integration of SPOT-5 image is important to combine a low-resolution colour multispectral image with a high-resolution grayscale panchromatic image to produce a high-resolution fused colour image (Source: http://www.math.ucla.edu, Accessed: 10 January 2015). Moreover, this shoreline study can be extracted and identified based on sea features, vegetation features, development area features and natural ground features as depicted in Figure 3.

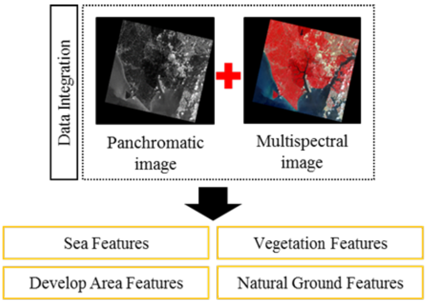


Fig.3 Integration of SPOT-5 image to extract shoreline

A. Sea Features

The extraction of water bodies and land is time-consuming and challenging when using the traditional approaches. Numerous research on shoreline extraction shall be developed to cater this problem. Besides, the absorbing methods for visualisation of shoreline erosion are essential to surge public awareness of the shifting shoreline and for combining disparate data into a consolidated framework. Therefore, the detection of shoreline erosion by using GIS and remote sensing technology has been in high demand over recent decades. Consequently, remote sensing method is a current tool to map the changes in shoreline erosion in an agile and cost-effective way [22]. Multitemporal satellite images are the recent remote sensed technology that utilises high dimensional colour reflectance to characterise the topographic and geoinformatics data. However, multi-temporal data lead to variations of georeferencing to different coordinates. Therefore, a unified method is needed to standardise this geo-referenced mapping. Some examples of research to detect shoreline changes in China with remote sensing are from Yellow River Delta, where successful studies have been carried out on shoreline changes and urban expansion using multi-temporal satellite images [28]. Besides, the shoreline is extracted by manipulating the channel images where water and land can be separated directly [29]. As depicted in Table 5, a comparison of shoreline extraction method is shown. According to [30], by using sub-pixel precision, the position of the shoreline can be extracted. Therefore, it may be a useful tool for changing shoreline knowledge. However, there are some issues on tidal ranges improved during ebb tide. The sub-pixel edge detection cannot perform well at object corners [25]. The monitoring of coastal areas is an important process in steady development and environment maintenance. Changes in shoreline positions might be due to either a single issue or a combination of many consistent factors. Spatial-temporal shoreline dynamics are initiated by natural influence, such as tidal, storms, marine currents and beach geomorphology and man-induced factors like a coastal explosion, deforestation, and engineering activities, contributing to consider impacts on coastal environmental zones. Temporal changes in shorelines are determined by interannual and decadal-scale fluctuations at atmospheric and hydrodynamic forcing, while the spatial variation is a function of geological and geomorphological conditions, which control the shoreline erosion and sediment amount [31]. Shoreline mapping and change detection are necessary for safe navigation, resource supervision, environmental protection, and sustainable shoreline development and planning [32].

Table 5: Comparison of shoreline extraction methods.

Method	**References**	**Advantage**	**Disadvantage**
Thresholding based Method	[21],[22]	• Removes cosine effect of different solar zenith angles. • Reflectance compensates for various values of exo-atmosphere solar irradiance arising from the spectral channel difference. • Reflectance is correct for variation in Earth-sun distance between acquisition data.	• Cannot be used to low tidal data. • Seasonal data.
Subpixel edge detection	[23],[24], [25]	• Suitable in an area with high tidal ranges. • Whether seasonal variability derived in the width of beaches or seas without tides. • Error estimation of edge location can be catered. • Highly accurate extraction of the edges.	• Not suitable for sectors with very low tidal ranges. • Edge detector cannot perform well at object corners.
Top of the atmosphere	[5]	• Better spectral resolution. • Uses automatic detection techniques for shoreline delineation.	• Not suitable for SPOT-5 images.
Statistical	[4], [26], [28]	• Accurate and robust prediction of shoreline changes. • Better accuracy and efficiency with minimal data required.	• Leads to progradation of the shoreline and for scheming two shoreline recession. • Low frequency.
Water-land separation	[27]	• Better discrimination between land and water. • Perform well in contrast enhancement method.	• Needs accurate information of edges.

B. Develop Area Features

Many researchers are exploring in the field of continuous natured feature extraction using satellite image processing. In the detection of develop area, the issue has been tackled using different approaches such as the model-based, edge-based and morphological-based approaches. For example, in the extraction of develop area using edge-based approach, footprints have been described with more details after eliminating the useless edges. Many studies regarding tracing the development area by outlining the boundaries have been using edge detection algorithm. However, it is a challenging method to extract the development area boundaries from other line segments with high accuracy by using satellite imagery. Therefore, researcher solves the problems by catering in different aspects such as building footprints from the digital surface model [33], Edge-Based [34] and shape identification [35]

C. Vegetation and Natural Ground Features

Many researchers have reported the use of Normalised Difference Vegetation Index (NDVI) for vegetation monitoring [36],[37]. This method is claimed to be effective in partitioning vegetation classes. Satellite sensors measure the wavelengths of light absorbed and reflected by green plants with the presence of chlorophyll. NDVI is the selected method in vegetation indices which estimates the measure of vegetation type, amount, and condition on the land surface. The method is expressed as in Equation (1) below:

$$NDVI = (Red – NIR) / (NIR + Red) \qquad (1)$$

In contrast, the Normalized Difference Water Index (NDWI) is a method to delineate water features and enhance the presence of natural ground and terrestrial vegetation features by manipulating NIR channel. Although there are numerous water indices, NDWI is one of the most widely used methods to estimate water bodies using multispectral satellite images [5]. The NDWI is expressed as follows in Equation (2) [38]:

$$NDWI = (Green – NIR) / (Green + NIR) \qquad (2)$$

IV. IMAGE ENHANCEMENT METHOD

Image enhancement is the modification of an image to resolve image problems and make image data more accessible to be interpreted as depicted in Table 6. Many researchers in recent years have focused on images taken in bad weather, often produces low contrast due to the presence of surface reflectance in the atmosphere, which reduces scene radiance [39]. Haze is one example of surface reflectance appeared from atmospheric absorption and scattering. In Peninsular Malaysia, from January to February and June to August, the zone is most expected to have a hazy atmosphere (Source: http://www.met.gov.my, Accessed: 1 December 2015). At high concentrations, these particulates scatter and absorb sunlight resulting in diminished horizontal visibility, thereby giving the atmosphere a characteristic called haze. The particles that cause the haze appearance might originate from many sources, which may occur in a natural way or from some anthropogenic factors. Natural sources include the oceans, forests, and the ground surface. However, the majority of the particulates are from human activities including open burning, land clearing, vehicular use and combustion of fossil fuels in industrial boilers. In the process of image enhancement, the noise will be removed from the images, and the image contrast will be enhanced. Low contrast images with weak edges pose challenges in the fields of computer version and pattern recognition[41]. However, the tropical hot and humid climate in Malaysia all year round is a challenging problem because of the relevance between the persistent cloud covers and hazy days. Removing the noises can increase the visibility of scene, correcting the colour shift affected by the air light [42]. For examples, in filtering, edge detection, and feature detection. Furthermore, the reflectance of a ground object by using atmospheric correction method can contribute to feature information extraction and feature recognition research. In short, Figure 4 presents the existing works that used to remove noise.

In general, the remote sensing image is captured with a high-quality image. Many research on remote sensing has been widely applied in various fields including agricultural, forestry, shoreline and hydrology sectors. However, remote sensing is usually exposed to surface reflectance issues due to images were taken at a substantial distance from the earth's surface [43]. In multispectral imagery, it uses the passive sensor to measure reflected sunlight emitted from the sun. Consequently, in a tropical country, the sun's energy cannot extend the sensor before it passes through a significant atmospheric path. Therefore, the multispectral imagery in the tropical country might be degraded by haze, fog, and clouds. The image is substantially prone to lose contrast and brightness, and this condition reduces the visual quality of the image [43], [44].

Surface reflectance is traditionally an atmospheric phenomenon due to the effect of dust, smoke and other dry particles obscuring the clarity of the atmosphere. Images with surface reflectance condition will reduce the visibility, and low contrast images reduce the performance of various image processing and computer vision techniques [45]. The dehazing method is a standard technique to remove surface reflectance and ensure high image visibility, as well as to correct the colour shift caused by the airlight [46].Besides that, remote sensing application commonly uses computer vision algorithms for feature detection and image filtering. The image with the presence of surface reflectance issues is prone to have biased low contrast scene radiance. However, haze removal has been a challenging issue where the hazy situation is dependent on the unknown depth information. Accurately by estimating the airlight and recovering the lost details of images, image processing is becoming quite a challenge. Therefore, haze removal study has attracted much attention to demonstrate the effective techniques for real-time applications.

Many approaches have proposed for addressing the problem of surface reflectance condition such as hazy and cloudy conditions. These approaches are categorized into two types: multiple image processing or additional information methods [40],[47],[48],[49] and single image processing

Table 6: Comparison of image enhancement method.

Category	Method	References	Advantage	Disadvantage
Remote Sensing image	DCP	[43]	• Refine airlight colour estimation by exploiting the differences between NIR and RGB channels. • Fast speed.	• Not suitable for sky area. • May lose effectiveness for images with large haze gradients.
	Histogram Equalization	[41], [43],[55]	• Contrast of the images was increases. • Better efficiency. • Enhance image effectively. • Simple and efficient for scenes where depth changes are abrupt. • An efficient method to recover the dark image.	• Cannot be used to restore contrast of moving objects.
	Decorrelation Stretching	[56], [62]	• a higher accuracy of cloud detection • upgrades colour division crosswise over very associated channels	• Not able to correctly detect all the various types of clouds in an image
RGB image	DCP	[10],[[61], [62]	• Can directly calculate the thickness of the haze. • Effective per-pixel computation.	• DCP will become invalid when the scene objects are substantially similar to the atmospheric light.
	Co-occurrence Histogram Equalization (COHE) and DCP	[62]	• Commonly used methods. • Effective to equalise a grey-level. • Useful in improving colour images with low contrast.	• Some pixels have low intensity.

approaches [10], [43],[44], [46],[50],[51]. In multiple image processing or additional information approaches, haze can be removed by polarisation method which eliminates the haze by using two or more images of the same scene taken under different weather conditions [46]. According to [47], more limitations are identified from many images of the same scene taken under different weather conditions [50]. Therefore, in many cases, it may not be possible to remove the noise by using multiple images [44]. Since then, the dehazing algorithm is widely used to remove noise in images. Multiple images estimate the purpose of removing noise or increasing the contrast with the different amount of noise or additional information. Long [43] used a low-pass Gaussian filter to refine the coarse estimated atmospheric veil to retain, and colour distortion of the improved images can be obstructed. However, the existing dehazing algorithm cannot remove dense haze and produce low contrast images because of the incorrect estimation of scene depth [42].

A. Dark Channel Prior

Numerous experiments have established that a single image processing approach can remove the noise by maximising the local contrast of the single restored images [51]. The air light is smooth when the image is free of noise. The images resulting from Tan's method tended to be oversaturated and can yield halo artifacts. Fattal [52] assumed that the transmission and surface shading are uncorrelated. However, this approach might fail in case of highly dense noise. Kaiming et al. [46] used simple approaches in the dark channel prior (DCP) algorithm based on the observation that very dark channel pixels exist in natural scenes. In the DCP approach, the air light estimation in the dark pixel has increased at different distances and a depth of map is obtained which is used to improve the scene radiance. Since the DCP may be invalid when the scene is similar to the air light over the vast region, this approach may fail in some cases. [53] developed the haze optimised transformation (HOT) method to identify and remove the haze region of the Landsat thematic mapper/enhanced thematic mapper area. [43] used a low-pass Gaussian filter to refine the coarse estimated atmospheric veil to retain excellent details and colour distortion of the recovered images obstructed. However, the existing dehazing algorithm cannot remove dense haze, and it produces low contrast images because of the incorrect estimation of scene depth [42].

B. Histogram Equalization

Besides, the image was taken with poor contrast usually contains unevenly distributed grey values. Many research in recent years have proven to utilise Histogram Equalization (HE) method where it has managed to stretch the contrast by uniformly distributing the gray values [41],[57],[54],[55] For instance, as depicted in Table 1, a comparison of the image enhancement method is shown by two section categories; Remote Sensing image and RGB image. This approach enhanced the quality of an image. Therefore, HE is another method used in haze removal by improving the image contrast from histogram stretching. For example, histogram stretching is conducted based on Grey Level Grouping method applied in low contrast and low bright colour image [41]. However, due to the images having surface reflectance condition with low contrast and low bright colour image, the contrast degradation of the problem images cannot be adjusted by depending only on dark channel algorithm [45]. Therefore, the noisy image needs to be enhanced and the contrast is improved before the image can be analysed. Moreover, the low contrast images with weak edges pose challenges in the fields of computer version and pattern recognition [41]. [10] Proposed that the dissimilarity between the colour (RGB) and NIR channels for air light estimation can be exploited to recover a noisy image and the colour distribution. By using this method, the NIR channel can penetrate further than the visible channel in the haze [10]. Dehazing can increase the visibility of the scene by correcting the colour shift caused by the air light [42]. Image enhancement method can produce in-depth information and bring out the advantage of many images processing which includes filtering, edge detection, feature detection and advanced image editing.

C. Decorrelation Stretch

Decorrelation stretch enhances the colour separation in an image with significant channel correlation [56]. The exaggerated colours can improve visual interpretation and identify features easier [57]. The original colour value of an image is mapped to a new set of colour values with a broader range. This method is applied to three channel images; RGB images or RGB multispectral composite images. This approach can achieve a higher accuracy result for cloud detection [57]. Besides, decorrelation stretch has managed to identify vegetation by the spectral reflectance [58].

V. IMAGE FILTERING METHOD

As depicted in Table 7, the issues identified on satellite image can be categorised into two, noise and missing line cues. In order to filter the noisy feature caused by the aforementioned natural influences, an improved filtering method will be analysed and proposed. Based on supervised classification methods, by making a direct evaluation on the two multi-temporal images considered, without depending on any additional information, it involves the availability of a multi-temporal ground truth to derive a suitable training set for the learning process of the classifiers [6]. Image filtering can enhance and smoothen the remote sensing images. Thus, edge enhancement is beneficial in remote sensing images. Edge enhancement is also appropriate in detection lineament and structural details in geological studies. The application includes the detection of shoreline and coastal agriculture.

Remote sensing image is often corrupted by random variation intensity or low contrast effect. For example, in an image with sedimentation, shadow and clouds may appear in low contrast condition. Table 8 presents the existing filtering method to address the surface reflectance problem while preserving the image information. [20] developed a method using single radar images for detection and extraction of shoreline. They used Lee Sigma filter for removing speckles and median filter for land and water enhancement. Lee Sigma filter is useful in speckle filtering [64]. However, most researchers commonly use speckle filter method; the result images will cause the loss of image information [20]. Other than Lee Sigma and Speckle filter, Wallis filter is a particular filter which improves image contrast and suppresses noise at the same time[59]. Encouraged by prior studies, some research combined two filters to reduce every possible noise existed [60]. A multispectral image with the existence of surface reflectance is prone to have low contrast. According to Chiabrando et al., Wallis filter can remove luminance noise [60]. Therefore, a comprehensive study to improve surface reflectance problem while maintaining the detailed information on an image is highly recommended.

Table 7: Issues on satellite image in shoreline detection

Category	Method	References	Advantages	Disadvantages
Noise	Gaussian Filter, Lee-Sigma Filter, Wallis Filter	[63],[64], [20], [60] [59]	• Preserve edge information. • Clarify low contrast efficiently while preserving edges.	• Slightly blur at the edge.
Missing edge line cues	Median Filter, Subpixel Edge Detection	[20], [27]	• Preserve sharp edges. • Improve the images and discriminate the boundary between land and water.	• Only cover the spectral amplifying to extract a distinctive border.

VI. SHORELINE DETECTION FRAMEWORK

A few decades ago, global sea level increased by about 1.6 mm/year. Sea level has risen due to the climate change which includes ice melt and the warming oceans. This process is expected to cause the movement of the shoreline. The shoreline movement is changing continually within time due to the result of on-offshore, sediment transport and dynamic nature water level such as waves and tide [6]. The shoreline is inherently dynamic features occurring between land and sea. Monitoring the shoreline is a difficult phase to manage over appropriate time and spatial scale. However, in recent year's shoreline zone monitoring, the extraction and analysis of shoreline detection have attracted much attention of the researchers due to the dramatic effect of variations in the shape of the coastline. Therefore, shoreline mapping and change detection are essential in safe navigation, resource management, environmental protection and sustainable shoreline development and planning. Challenges posed when using traditional ground survey techniques sometimes make it impossible to monitor the shoreline changes for the vast

Table 8: Comparison of filtering method.

Method	Data	References	Advantage	Disadvantage
Subpixel Edge Detection Filter	TM, ETM and ETM+ Landsat images	[20],[27],	• Preserve sharp edges. • Improve the images and discriminate the boundary between land and water.	• Only cover the spectral amplifying to extract a distinctive border.
Lee-Sigma Filter	RADARSAT-1 image	[20]	• Reduce random noises. • Beneficial for monitoring shoreline changes during high & low tides & shoreline erosion in a tropical country.	• Slightly blurry.
Speckle Filter	SAR image	[65], [66]	• Luminance noise reduction. • Smoothing capabilities.	• Images information lost.
Median Filter	RADARSAT-1 Landsat image	[20]	• Speckles removed. • Smoothen the image appearance • Edge information preserved.	• Less efficient in removing random intensity noise.
Gaussian Filter	RGB image	[63], [64]	• Clarify random intensity noise effectively while preserving edges.	• Slightly blur at the edge.
Wallis Filter	UAV	[60]	• Luminance noise reduction. • Image contrast enhanced.	• Less efficient in removing detailed noise.
Mean and Median filters	RGB image	[67]	• Remove the noise while preserving the edges	• Incomplete noise suppression
Median filter and Weiner filters	RGB image	[68]	• Remove the blurriness	• Less accurate in reducing noise.

amount of coastal areas which involve difficult tasks and time-consuming. Consequently, in recent years, remote sensing methods have become a popular method to overcome such difficulties, cost efficient and a useful tool to map the shoreline.

Satellite images developed by remote sensing technologies using air, space and land-based techniques, present the shoreline in data format ripe for analysis in GIS. Hence, topography map and aerial photograph are the examples of archived data sources digitally exploited in GIS following the process of digitising or scanning. Moreover, these data sources can offer a useful database to evaluate the historical rate of change of shoreline. The shoreline detection is essential because remote sensing satellite images provide digital imagery in an infrared spectral channel where the extraction of land water is well defined [69]. Hence, by integrating remote sensing techniques and GIS, the researchers have managed to develop a valuable tool for analysing and extracting reliable and dependable information.

Delineating shoreline for environmental conservation with remote sensing assessment is essential for shoreline management and mangrove conservation purpose. The shoreline is extracted using edge detection techniques before delineating process. Edge detection is important to identify and locate sharp discontinuities of an image which is influenced by image brightness. Therefore, this process is an essential tool in image processing and computer vision particularly in the areas of feature detection and feature extraction. Besides, once the low contrast imagery has been enhanced and the shoreline edge has been preserved, precise recognition and extraction of shoreline can be performed [20]. Hence, shoreline detection framework is essential and reliable by integrating the image enhancement and image filtering method for better feature extraction to facilitate the shoreline edge detection. Figure 4 shows a comparison of a flowchart for each category. Table 9 shows several remote sensing images are used in shoreline detection method.

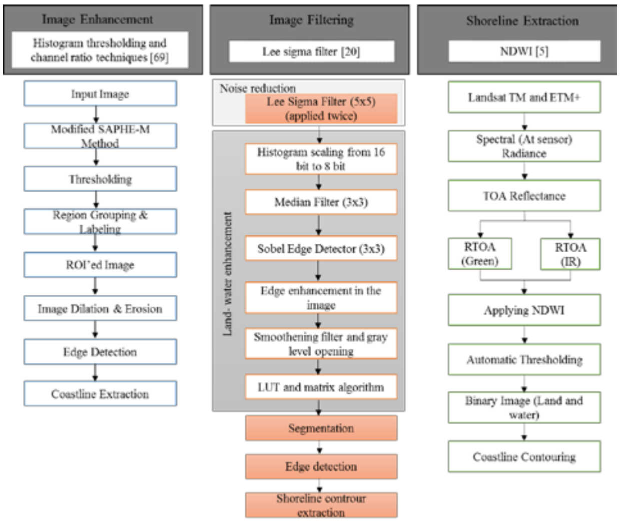


Fig.4 Example comparison of flowchart in shoreline detection method.

The extraction process of water bodies and land is time-consuming and challenging when using the traditional approaches. Recently, many researchers have directed their

Table 9: Comparison of data sources in shoreline detection method.

Category	Method	References	Data Sources	Description
Image enhancement	Histogram thresholding and channel ratio techniques	[69]	TM and ETM+ sensor	Misclassify in between vegetation of land and water
	Modified Self-Adaptive Plateau-Histogram Equalization with Mean Threshold (Modified SAPHE-M) and median filter	[1]	Indian Remote Sensing Satellite (IRS P6) LISS-III	Improve significant contrast enrichment of coastal edges and coastal objects for more precise recognition and delineation
Image Filtering	Lee sigma filter	[20]	RADARSAT-1 SAR image	Essential in extracting and delineating the coastline
Shoreline extraction	NDWI, MNDWI, AWEI	[71]	Landsat	NDWI index produces the best result in extraction, in the Kizilirmak Lagoon Series and delta shorelines
	NDWI	[5]	Landsat Multi-spectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+)	Improve the accuracy and a useful tool for shoreline extraction in Landsat satellite images.

Attention to the detection of shoreline by using satellite images. According to [30], by using sub-pixel precision, researchers can extract the position of the shoreline. Therefore, it may be a useful tool for shoreline detection knowledge. However, there are some issues on tidal ranges that can be improved during ebb tide. Moreover, subpixel edge detection cannot perform well at object corners [25]. Other than that, remote sensing image is often corrupted by random variation intensity or having low contrast. For example, in an image that has sedimentation, shadow and clouds may appear in low contrast condition. Besides, shoreline change is a complex phenomenon which affects the shape of shoreline and mangrove forest. Shoreline changes are caused by coastal erosion where the result can either be from the natural or anthropogenic factors [5]. For countries with significant shoreline extensions such as Malaysia, remote sensing is a robust, cost efficient and fast method for shoreline management which includes coastline mapping and change detection. [18] have examined the pattern of erosion-accretion changes in Yellow River Estuary, China by utilising TM and ETM+ images. [24], used Landsat TM and ETM+ multi-temporal images to extract the shoreline in Spanish Mediterranean coast. [6] used SPOT 1, 2,3,4,5 and FORMOSA-2 to estimate shoreline position and changes in tidal variation. Besides, according to [70], the maximum contrast of the sea and land can be developed by extracting satellite-derived shorelines. [1] improved the coastal edges and coastal objects for clearer recognition and delineation by utilising the adopted Modified Self-Adaptive Plateau histogram Equalization with method threshold. In contrast, [69] method misclassified the vegetation of land and water. Unfortunately, these methods do not expose the surface reflectance condition.

VII. CONCLUSIONS

Throughout this study, an extensive review has been conducted in investigating the shoreline detection framework that incorporating the image enhancement and image filtering method. This study presents the basic concepts of shoreline detection regarding its dense pattern of the research area and issues. The specific research of interest which includes the computational method of shoreline detection for extraction of features due to the existence of low contrast, missing line cues, and the error of edge location by using remote sensing data. Hence, efficient framework involving in remote sensed images, statistics, and ground truth validation is needed to detect the shoreline more precisely. Moreover, it is important that future research in applied geography continue to monitor the shoreline changes to support planning strategies that protect the ecotourism and conservation values.

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