URBAN ANALYTICS ON GREEN COVERAGE IN MALAYSIA WITH STREET VIEW IMAGES

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URBAN ANALYTICS ON GREEN COVERAGE IN MALAYSIA WITH STREET VIEW IMAGES

CHONG XIAN JUN

A proposal submitted in partial fulfilment of the

requirements for the award of the degree of

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this project proposal, I am very much indebted to my supervisor Ts. Dr. Chan Weng Howe for his useful advice. I would also love to express my gratitude for my friends who had helped me out in this project.

ABSTRACT

ABSTRAK

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LIST OF ABBREVIATIONS

|  |  |  |
| --- | --- | --- |
| ANN | - | Artificial Neural Network |
| GA | - | Genetic Algorithm |
| PSO | - | Particle Swarm Optimization |
| MTS | - | Mahalanobis Taguchi System |
| MD | - | Mahalanobis Distance |
| TM | - | Taguchi Method |
| UTM | - | Universiti Teknologi Malaysia |
| XML | - | Extensible Markup Language |
| ANN | - | Artificial Neural Network |
| GA | - | Genetic Algorithm |
| PSO | - | Particle Swarm Optimization |
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LIST OF SYMBOLS

|  |  |  |
| --- | --- | --- |
| δ | - | Minimal error |
|  | - | Diameter |
|  | - | Force |
|  | - | Velocity |
|  | - | Pressure |
|  | - | Moment of Inersia |
|  | - | Radius |
|  | - | Reynold Number |
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# INTRODUCTION

## Problem Background

Urban greens, including trees, shrubs, and associated vegetation in cities, have long been recognized for their importance in the urban environment. In fact, there have been countless studies in recent years reiterating the instrumental importance of urban forests or trees in lowering urban temperatures and creating more comfortable microclimates (Pauliet, 2003; Schwaab, 2021), providing physical and mental health benefits (Lee, 2010), etc. making the urban areas more livable for its inhabitants.

Unfortunately, there are hardly any regulations guiding the management of urban greens in Malaysia. The Malaysian urban landscape planning practices are mostly based only on open space coverage (Rusli and Rudin, 2010). For instance, under the National Urbanization Policy (NUP), two hectares of open space per 1000 urban population were set as the planning standard and a minimum of 10% or 0.2 hectares of open spaces are dedicated for all development (NUP9.ii). While open spaces are an essential part of urban greens, this single variable on itself is not enough to provide comprehensive data to inform planning that can optimize the experience of the places’ inhabitants.

Along with the increase in global awareness on the importance in urban green spaces, urban green space is increasingly seen as an integral part of cities planning (James, 2009), fueling the growth of research in this field. According to the systemic review based on PRISMA framework by Rajoo et. al. (2021), there is a growing trend in research articles concerning urban forests in Malaysia from 2007 onwards. Out of the 43 records reviewed, only 4 of them were focused on the spatial analysis of urban green space (Kanniah, 2017; Masum et. Al., 2017; Kasim et. Al., 2019, Nor et. Al., 2019). This shows an untapped opportunity where the spatial analysis on urban green coverage in Malaysia can be investigated.

Nevertheless, all of the spatial studies are based on macro-scale aerial views, making them not representative of the human experience on the ground level on the day-to-day micro level. While these studies are essential, they are not able to relate to the direct human user perspectives when they are in the city. In other words, satellite imagery is useful for high level planning of preservation and restoration, but not informative for the environmental design of the everyday human experience.

It is long overdue that we adopt better metrics to measure urban greeneries coverage that can allow us to integrate urban green into our daily experience in the Malaysian urban environment.

## Problem Statement

In this study, we try to tackle the problem by measuring and mapping urban green in a Malaysian city to analyze its coverage from the eyes of the users. In other words, this study measures: “how much greeneries can people in a Malaysian city see?”

The quantified study of the urban users’ views is made possible by the establishment of Green View Index (GVI), which makes use of street view images and detects the proportion of greeneries in the images collected. While the study is limited to the street views, the studies and information extracted remain to be highly informative for planners as the streets are the public space with the most human activity.

Nevertheless, there are several challenges to overcome in the study, which lead to our research questions.

## Research Questions

The questions that this research attempts to answer are:

1. How do we collect the large amount of street view data required as the raw data to and study the urban green coverage?
2. Given the large amount of street view images, what kind of learning algorithms can we use to compute GVI efficiently?
3. How do we interpret and analyze the computed GVI and make it informative for the urban planning process?

## Aim and Objectives

The aim of this project is to visualize the state of urban green coverage in Malaysian city from the users' perspective with Green View Index (GVI). Dashboard is developed as the final output that allows us to interpret the findings intuitively. Objectives of this research are as follow:

1. To collect and process street view images data to measure urban green coverage from the perspective of human users.
2. To compute GVI effectively from street view images with unsupervised segmentation and supervised machine learning models.
3. Develop a dashboard to visualize the estimated GVI of selected sites and assess the distribution of green views in Malaysian city.

## Scope of Study

Due to limitations in time and resources, a smaller scope in Johor Bahru city center is chosen as a representative sample site for this study. It is chosen due to it being the central hub of Johor Bahru with a high population density. As there are no official boundaries demarcating the Johor Bahru city center area, local experience is used to help formulate the definition of city center area. In this case, the main road *Jalan Lingkaran Dalam* acts as the edge of the city center.

Meanwhile, the street views images used to compute GVI are collected in December 2022 from the Street View API provided by Google Maps due to its availability and accessibility. As the site has a nearly eclipse outline, the actual boundary of the studied site is approximated by a circle to facilitate the function of Google Maps. With several experimentations, the sample site is set to be a circle with a 1000m radius from the *Komtar JBCC*.

Diagram

Description automatically generated with low confidence  
Figure 1.1 Site plan boundary.

## Significance of Study

The project is expected to provide comprehensive insights on the urban green coverage from users’ perspectives measured by GVI in Johor Bahru city canter. This information will be useful to inform the process of urban planning of the said area, while also shining some light on the conditions of the other similar urban areas in Malaysia.

## Project Organization

The project is laid out in 5 chapters, in the first chapter we go through the introduction to the problem background and statement, research questions and objectives, along with the scope to establish the framework of study. In Chapter 2, extensive literature review is done to understand the state of urban greeneries research in Malaysia, the use of GVI and the methods used to compute GVI. Several methods are reviewed, and their respective evaluation metrics are explored. In Chapter 3, detailed methodology for the project procedure is established, from data preparation to model development and evaluation, and lastly reporting. Chapter 4 cover initial findings about GVI in the study site. Chapter 5 concludes the project with its achievements, limitations and how it can be improved.

# LITERATURE REVIEW

## Overview of Literature Review

By and large, urban greeneries in Malaysia are managed only very indirectly through the management of open space coverage. However, this is hardly an effective measure to optimize the effects of tree coverage in the urban environment.  Thus, various studies on urban forests were published to investigate various effects of urban greeneries, e.g. in ecology, biodiversity, accessibility, etc. In this project,  the Green View Index (GVI) measured by using street view images along with machine learning algorithms is proposed as another metric to augment the urban planning process in Malaysia.

While previous studies have successfully established the methods to measure and compute GVI in cities, there is still room for improvements in this area, particularly in the context of Malaysian urban areas.

In this literature review, we will study the research questions in several different sections. Firstly, we will establish the background context by reviewing the existing studies of urban greeneries coverage in Malaysia. Later, we dive into the literature discussing the importance and the methods to measure GVI. Lastly, algorithms and models developed in previous studies to detect and compute GVI from the street views are explored to find out the most efficient way to adopt for this project. The extracted insights will provide a foundation for our study, which aims to investigate the GVI measurement in Johor Bahru city center.

## Research on Urban Greeneries in Malaysia Limitation

In Malaysia, the management of urban greeneries are based crudely on the measurement of open and green space (land specified as public area, loosely correlated with green area) coverage according to the Department of Town and Country Planning, Peninsular Malaysia (JPBD). Several standards are established, e.g., 2 hectares of open space are reserved for each 1000 urban populations, green areas to be established as buffer zones to limit urban development. While these measurements are essential for sustainable urban planning, they are not sufficient to optimize the urban greeneries.

While there is a lack of urban greeneries management practice, there are various research being done in Malaysia attempting to fill in the gap. In a systematic review done on urban forestry research with PRISMA framework (Rajoo et. al., 2021), there is a consistent growth in the research concerning urban forests in Malaysia from 2007 onwards. Nevertheless, out of the 43 records reviewed, only 4 of them were focused on the spatial analysis of urban green space (Kanniah, 2017; Masum et. Al., 2017; Kasim et. Al., 2019, Nor et. Al., 2019). This shows an untapped opportunity where the spatial analysis on urban green coverage in Malaysia can be investigated.

On the topic of urban green spatial analysis in Malaysia, the researches done are typically conducted based on aerial images on macro or micro planning scale. For instance, on a high-level master planning scale, Kasim et. al. (2019) published a study that documented the changes in urban green spaces between 2002, 2012 and 2017 with the use of high-resolution aerial imagery; Kanniah (2017) made use of time-series Landsat satellite imagery to monitor green cover changes in Kuala Lumpur from 2001 to 2016. On the lower-level planning, Ludin and Rusli (2009) monitored the quality and distribution of open spaces in Johor Bahru Tengah Municipal Council with remote sensing data.

However, all of the studies mentioned above are investigated with aerial top-down view for instrumental planning. However, top-down view studies are abstract and not directly informative for the environmental design of the everyday human experience, making it not relatable to the end-user experience. To the best of our knowledge, there is no objective study done from the perspective of urban environment users, which is a crucial measurement central to the planning of experience of the users in the urban environments. This leaves a research opportunity for such a project to happen.

## Green View Index (GVI) with Street Views

Conventionally, aerial remote data has been used for the task of trees mapping or any other similar land surveying tasks. Even with the advancement of new techniques such as remote sensing methods such as LiDAR, aerial top-down view remains to be the main perspective in which urban greeneries coverage is measured.  However, we have all known that the top-down view is hardly how we humans experience our environment as we perceive it in a perspective view, making the studies being hard to relate for the end-user experience of urban dwellers.  This is especially relevant in urban environments where man-made facilities are juxtaposed with the mixture of trees, forming urban treescapes with massively different appearances for the same green area.

Many studies have attempted to study the visual impact of urban trees. However, a lot of them were qualitative and subjective in nature (J. Yang et. al., 2009). One of the most popular methods used were ranking, in which the participants of the survey were shown pictures or videos of urban forests and requested to score the pictures. It does not take much to understand the limitations of the studies: qualitative, subjective and unscalable. J. Yang et. al. (2009) established a new metric called Green View Index (GVI) which measures the amount of greenery that people can see on the ground at different locations in a city, laying the foundation for all the future quantified studies of visual effect of urban treescapes.

The index calculation was simple but ingenious. On strategically sampled points on a target site, eye-level photographs were taken at each point and the GVI index of each point was then interpreted by calculating the ratio between areas containing foliage over the areas of whole photos. In short, it can be defined as the ratio of greenery within the people’s field of view with a range between 0 and 1, of which 0 represents no greeneries at all and 1 means that the image is full of greeneries. Due to the streets being the main public space where urban dwellers experience, Green View Index (GVI) is typically measured by using images taken from the street. The formula to calculate GVI is shown in Equation (2.1) below. M refers to the total number of pixels in one GSV image, n refers to the number of images used to calculate the GVI on a single point; refers to the area of a GSV image covered by greeneries, while refers to the total area of a single GSV image.

(2.1)  
Equation (2.1) shows the formula to calculate GVI.

After the establishment of GVI, it has since become the foundation for future researchers to conduct quantitative studies on urban treescapes for landscape and urban planning studies. With the development of services like Google Street View, GVI has become even more viable as a technique to map urban green view and become an increasingly popular metric for urban green space research. Table 2.1 displays several examples of the use of GVI in various studies and their applications.

Table 2.1 Examples of other GVI studies and their applications.

|  |  |  |
| --- | --- | --- |
| Application | Study | Discussion |
| Investigate green view distribution | View-based greenery: A three-dimensional assessment of city buildings’ green visibility using Floor Green View Index (Yu et. al. 2016) | GVI is modified to Floor Green View Index (FGVI) to quantify the area of visible urban vegetation from a certain floor of building. |
|  | How green are the streets? An analysis for central areas of Chinese cities using Tencent Street View (Long and Liu, 2017) | Analyze street greeneries in 245 central area in Chinese Cities and detect patterns of street green view distribution. |
|  | Treepedia 2.0: Applying Deep Learning for Large-scale Quantification of Urban Tree Cover (Cai et. al., 2018) | Develop deep learning method to compute GVI with significantly higher accuracy. |
| City walkability | Analyzing the effects of Green View Index of neighborhood streets on walking time using Google Street View and deep learning (Ki and Lee, 2021) | Use deep learning to compute GVI and find out its relationship with walking time. |
| Socioeconomic investigation | Who lives in greener neighborhoods? The distribution of street greenery and its association with residents’ socioeconomic conditions in Hartford, Connecticut, USA (Li et. al., 2015) | Aggregate GVI at the block group level to compare differences in GVI based on the socioeconomic status of an area. |

## 2.4 GSV configurations for Street Views Collection

One of the greatest limitations of J. Yang et. al.’s study was the excessive resources required for data collection on large scale as it involved extensive manual labor to take street view photos. With the advancement of mapping services, it has become a lot easier for us to retrieve our needed street view images via Google Street View API without needing to manually take the photos of tree coverage on the street. Other than the ability to collect a larger amount of data easily, the use of Google Street View (GSV) also allows us to be more precise on our camera settings to get unbiased data for urban street treescape mapping. However, the use of GSV requires its users to have a clear understanding on the image taking configurations for the image collection.

One of the good references for this is the street-level urban greenery assessment conducted by Li et. al., 2017. They sampled 258 points of street view data collection randomly across its study site, with at least 100m intervals on average between each point. To ensure each sampling point includes all the green areas that a pedestrian can possibly see, they took 3 panoramic views upwards, straight and downwards. In the Google Street View API parameters, the “heading” was set to 0, 60, 120, 180, 240, and 300 respectively to capture a full 360-degree panorama; the “pitch” was set to −45, 0, and 45 to capture different views and 18 images were taken at each sampling point.

In fact, other than the method mentioned above, there have been many street view image configurations used in different research for different purposes. Dong et. al. (2018) reviewed multiple street view configurations used by previous research. In their review, they used Tencent Static Image (TSV) service to simulate all the GSV configurations coming up in other research.

Table 2.2 Different configurations of GSV

|  |  |  |
| --- | --- | --- |
| Configuration Name | Description | Discussion |
| GVI4 | GVI computed with 4 horizontal TSV images with heading angle of 90◦. (Long and Liu, 2017) | Greater numbers of headings allow for a lower field of vision (zoomed in), but also takes up more computational resources to compute. |
| GVI | GVI computed with 6 horizontal TSV images with heading angle of 60◦. (Zhang and Dong, 2018) |
| GVI8 | GVI computed with 8 horizontal TSV images with heading angle is 45◦ (Dong et. al., 2018) |
| GVI18 | Similar approach as method used by Li et. al. GVI computed with 6 horizontal TSV images with heading angle of 60◦ and 3 pitches for each heading. 18 images taken in total. (Li et. al., 2015) | Very comprehensive, but computationally expensive. |
| PGVI | GVI computed with cylindrical panorama stitched together from 6 horizontal TSV pictures. The distortion for PGVI might affect accuracy of GVI. (Cheng et. al., 2017) | Cylindrical panorama cause distortion in views. |

While there are many configurations used, it is important that one experiments with different configurations and chooses a configuration that can minimizes distortion and overlap to reduce error in GVI estimation.

## Prediction Models for GVI

Yang et. al. (2009) made GVI calculations by manually selecting areas containing foliage using Adobe Photoshop selection, which is time and resource consuming and requires lots of automation.

### 2.5.1 Unsupervised Segmentation Model

Li et. al. (2015) assessed the tree coverage in each image by extracting the green pixels with the unsupervised segmentation method, As pixels consisting of vegetation have typically higher reflectance values in the green band than red and blue, pixels consisting of greeneries can be extracted by selecting only the pixels with higher values in green band than red and blue. Nonetheless, it risks inaccuracies by including non-tree green objects and omitting shaded parts of trees that appears to be not green enough.

A picture containing sky, outdoor, road, green

Description automatically generated

Figure 2.1 example of green pixels that are not actual greeneries

#### 2.5.2 Deep Learning Model to Predict GVI

With the advancement of deep learning and computer vision models, semantic segmentation can be deployed to detect and mask the greeneries in street view images effectively. One of the most common deep learning algorithms for the task is convolutional neural network (CNN). Convolutional neural networks (CNNs) are a type of specialized neural network for processing data with a grid-like topology (LeCun et al., 1997) that have been widely used for image classification and other computer vision tasks by learning hierarchical representations of the data through the use of convolutional layers (Katole et al., 2015).

The basic building block of CNN is a convolutional layer. It extracts features from the input data by applying a set of learnable filters to the input data. These filters are designed to learn different features at different scales, such as edges, corners, textures, and patterns to produce a set of feature maps. By stacking up the convolutional layers in a neural network, the architecture allowed the use of hierarchical representations to effectively capture the spatial relationships between pixels in an image and learn complex patterns and features by itself as shown in Figure 2.2.

Diagram

Description automatically generated  
 Figure 2.2 Diagram illustrating working principles of CNN.   
Source: https://www.semanticscholar.org/paper/Hierarchical-Deep-Learning-Architecture-For-10K-Katole-Yellapragada/f78e280123b1c0c68f84da3cc6c66615f6e7cebd/figure/0

On top of CNN, many deep learning models are developed for image segmentation, e.g. ResNet (He et. al., 2017), FCN (Long et. al., 2015), SegNet (Badrinarayanan et. al., 2017), etc. As there are too many deep learning models developed for image segmentation, it is beyond the scope of this study to conduct an exhaustive review on every single model. Instead, this review will include only models that have been used to compute GVI.

Table 2.3 Summary of the deep learning models used to compute GVI.

|  |  |  |  |
| --- | --- | --- | --- |
| Model | Method | Training and Calibration | Prediction Output |
| DCNN semantic segmentation (Cai et. al., 2018) | Pyramid Scene Parsing Network (PSPNet) (Zhao et. al., 2016) with 65,818,363 parameters | Pre-trained on full Cityscapes dataset, then trained on Cityscapes dataset, and finally on 320 GSV images collected by Cai et. al. | Pixel-segmented GSV image |
| DCNN end-to-end (Cai et. al., 2018) | Deep Residual Network (ResNet) (He et. al., 2017) with 28,138,601 parameters | Pre-trained on ImageNet dataset, then trained on Cityscapes dataset, and finally on 320 GSV images collected by Cai et. al. | Single GVI value between 0 and 1 |
| HRNet-OCR (Zhang and Hu, 2022) | HRNet-OCR model (Yuan et. al., 2019) with 10,500,000 parameters | Trained on Cityscape dataset without calibration | Pixel-segmented GSV image |
| FCN-8 (Yu et. al., 2021) | Details of models not provided | Trained on ADE20K dataset, fine tuned with GSV images collected by author. | Pixel-segmented GSV image |
| DeepLabV3+ (Xia et. al., 2021) | Based on DeepLabV3+ model proposed by Chen et. al., 2018) | Trained on Cityscapes dataset, fine tuned with GSV images collected by author. | Pixel-segmented GSV image |

As the details of FCN-8 model is not included in study, the accuracy measure is therefore not included in the accuracy comparison of models in Table 2.4.

Table 2.4 Accuracy comparison between both models

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | Mean IOU (%) | Mean Absolute Error (%) compared with true GVI | Pearson Correlation Coefficient with true GVI | 5-95% of GVI Estimation Error |
| Unsupervised Segmentation (Li et. al.) | 44.7 | 10.1 | 0.708 | -26.6, 18.7 |
| DCNN semantic segmentation (Cai et. al., 2018) | 61.3 | 7.83 | 0.830 | -20.0, 12.37 |
| DCNN end-to-end (Cai et. al., 2018) | NA | 4.67 | 0.939 | -10.9, 7.97 |
| HR-NetOCR (Zhang and Hu, 2022) | 80.6 | NA | NA | NA |
| DeepLabV3+ (Xia et. al., 2021) | 78.37 | NA | NA | NA |

According to the comparison of accuracies, we can see that HR-NetOCR (Zhang and Hu, 2022) has the highest mean IOU (%) and DCNN end-to-end model (Cai et. al., 2018) has the lowest mean absolute error compared with the true GVI. Thus, these two models will be selected and studied in this project.

#### 2.6 Performance Measure for GVI Prediction

Cai et. al. (2018) proposed two metrics to evaluate the performance of tree cover estimation, i.e. mean Intersection over Union (IOU) to measure the accuracy of the location of labeled greeneries pixels, and mean absolute error (MAE) for the accuracy of overall GVI.

In computer vision, the mean IOU is commonly used for object detection and segmentation. It is defined as the ratio between the area where predicted objects or pixels overlap with the target object over the area of the union of both (Padilla et. al.).  In the context of GVI computation, the predicted and target values are both the pixels consisting of greeneries in the street view images.

Diagram

Description automatically generated with medium confidence

Figure 2.3 Illustration of the intersection over union (IOU)

Source: <https://www.researchgate.net/publication/343194514_A_Survey_on_Performance_Metrics_for_Object-Detection_Algorithms>

The IOU of greeneries pixels can be calculated with formula shown in Equation (2.2). is the number of images in test data, refers to true positive predicted greeneries label in image i, refers to the false positive predicted greeneries label in image i, refers to the false negative predicted greeneries label in image i.

(2.2)  
Equation (2.1) shows the formula to calculate IOU.

As for the accuracy of GVI value, it can be measured with the usual evaluation metrics used in regression. For instance, root mean square error (RMSE) proposed and mean absolute error (MAE) by (Dong et. al., 2018) and (Cai et. al., 2018) respectively. A model with the lowest MAE or RMSE has the highest accuracy. Their formulas are as shown below as Equation (2.3), Equation (2.4). refers to the predicted label of a pixel, refers to the true label of a pixel. M refers to the number of pixels in a GSV image, n refers to the number of images in test set.

(2.3)

Equation (2.3) shows the equation to calculate RMSE.

(2.4)

Equation (2.4) shows the equation to calculate MAE.

Other than measuring the accuracy of prediction, Pearson correlation coefficient ( r ) is used to evaluate whether the predicted GVI can accurately model the underlying patterns in the true GVI. The calculation of Pearson correlation coefficient is demonstrated in Equation (2.5), where r is the correlation coefficient, is the predicted GVI value for image i, is the mean predicted GVI, is the true GVI for image i, is the mean true GVI.

(2.5)  
Equation (2.5) shows the formula to calculate Pearson correlation coefficient ( r ).

Finally, there is another metric used to evaluate the variance and distribution of the difference between predicted and true GVI, that is 5-95% Estimation Error. For this metric, closer the central value is to 0 and smaller the range of the value is deemed to be better performing.

#### 2.7 Interpretation of GVI

GVI is defined to be the green view that one can see at a single point, typically on a street level. By combining the GVI extracted from many sampling points, one can connect the dots and come up with a comprehensive plot of the visibility of urban greeneries in the studied site. For instance, the Treepedia project by the MIT Senseable City Lab is mapping GVI across many major cities in the world to explore their green distributions.

Map

Description automatically generated Map

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Figure 2.4 Map plots of GVI for Amsterdam and Singapore as an illustration. Source:[Treepedia :: MIT Senseable City Lab](http://senseable.mit.edu/treepedia)

Other than directly mapping GVI on streets, the data can also be aggregated at an area-level by mean or median to ease the extraction of meaningful information by stakeholders such as planners and local governments. Nevertheless, there is a big potential to bias if the GVI is simply aggregated by the mean of points per area due to the difference in density of data collection. Kumakoshi et. al. (2020) modified the GVI calculation to propose a Standardized Green View Index (sGVI) as a weighted aggregation of GVI scores in a study area. The formula is shown in Equation (2.6). i represents the point of GVI calculation, while represents the total length of links (streets) that the point i is associated with, and is the total length of all links in the zone.

(2.6)  
Equation (2.6) shows the formula to calculate sGVI.

On top of the mapping of GVI or sGVI values on map, multiple secondary data such as the width of road (Dong et. al., 2018), ethnic distribution (Li et. al., 2015) can also be used to investigate the effects or reasons behind differences in GVI.

## Issues

Overall, there are multiple issues that can be identified from the literature review. To the best of our knowledge, there are no GVI studies in Malaysia, resulting in a missing potential to measure urban greeneries coverage from the users’ perspectives. As the computation of GVI was labor intensive (manual selection of greeneries), it is important that we choose an effective method to automate the extraction of greeneries from the street view images. In the literature review, we have come across multiple methods such as unsupervised segmentation (Li et. al. 2015) and deep learning models (Cai et. al., 2018) based on convolutional neural networks (CNN) such as PSNet and ResNet that were used by previous researchers for the task. It is important that we explore these methods and choose the most accurate and interpretable model to compute our GVI. Finally, it is also essential that we can visualise the computed GVI so that they can be interpreted effectively in meaningful ways to assist spatial planning of the cities.

# RESEARCH METHODOLOGY

## Research Framework

The aim of this project is to make use of machine learning to effectively map and analyze urban greeneries coverage in Malaysia from the users' perspective with Green View Index (GVI).  To achieve the aim, street view images on the representative sample site, Johor Bahru city center are collected from the Google Street View API, analyzed with machine learning to compute their GVI and interpreted on a dashboard. Figure 3.1 below illustrates the research framework planned for this study.

### Proposed Method

On the Insert tab, the galleries include items that are designed to coordinate with the overall look of your document. You can use these galleries to insert tables, headers, footers, lists, cover pages, and other document building blocks. When you create pictures, charts, or diagrams, they also coordinate with your current document look. You can easily change the formatting of selected text in the document text by choosing a look for the selected text from the Quick Styles gallery on the Home tab.

#### Research Activities

On the Insert tab, the galleries include items that are designed to coordinate with the overall look of your document. You can use these galleries to insert tables, headers, footers, lists, cover pages, and other document building blocks. When you create pictures, charts, or diagrams, they also coordinate with your current document look. You can easily change the formatting of selected text in the document text by choosing a look for the selected text from the Quick Styles gallery on the Home tab.

## Tools and Platforms

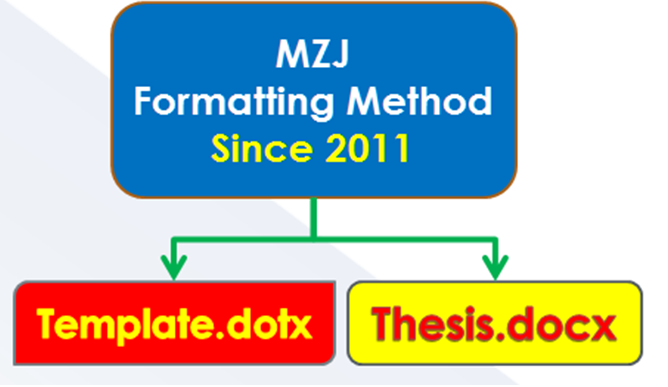


Figure 3.1 Example of Formatting Method

## Chapter Summary

1. Video provides a powerful way to help you prove your point.
2. When you click Online Video, you can paste in the embed code for the video you want to add.
3. You can also type a keyword to search online for the video that best fits your document.
4. To make your document look professionally produced, Word provides header, footer, cover page, and text box designs that complement each other.
5. For example, you can add a matching cover page, header, and sidebar.

# PROPOSED WORK

## The Big Picture

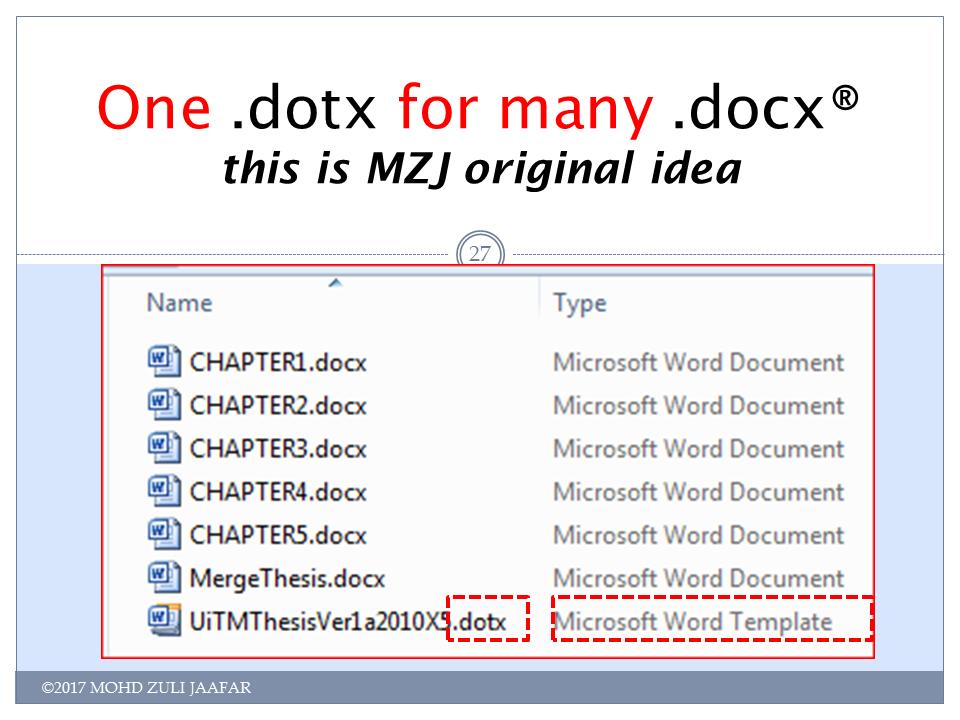


Figure 4.1 This is MZJ original idea

## Analytical Proofs

1. Video provides a powerful way to help you prove your point[[1]](#footnote-1)
2. When you click Online Video, you can paste in the embed code for the video you want to add.
3. You can also type a keyword to search online for the video that best fits your document.
4. To make your document look professionally produced, Word provides header, footer, cover page, and text box designs that complement each other.
5. For example, you can add a matching cover page, header, and sidebar.

## Result and Discussion



Figure 4.2 The method for hig performance formatting

## Chapter Summary

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# CONCLUSION AND RECOMMENDATIONS

## Research Outcomes

## Contributions to Knowledge

## Future Works

Video provides a powerful way to help you prove your point. When you click Online Video, you can paste in the embed code for the video you want to add. You can also type a keyword to search online for the video that best fits your document.

Table 5.1 Example Repeated Header Table

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Video provides a powerful way to help you prove your point. When you click Online Video, you can paste in the embed code for the video you want to add. You can also type a keyword to search online for the video that best fits your document. To make your document look professionally produced, Word provides header, footer, cover page, and text box designs that complement each other.

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Appendix A Mathematical Proofs

Appendix B Psuedo Code

Appendix C Time-series Results Long Long Long Long Long Long Long Long Long Long

LIST OF PUBLICATIONS

1. Mary Duncan Carterand Rose Mary Magrill, “Building Library Collections" Fourth edition. (Metuchen, N. J.: Scarecrow Press, 1974), pp.61 - 66. [↑](#footnote-ref-1)