TOURIST INTEREST MINING FROM ONLINE HOTEL PHOTOS

By

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To My Parents

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Student Declaration

I, Aleksandar Trpkovski, declare that the Master by Research thesis entitled TOURIST INTEREST MINING FROM ONLINE HOTEL PHOTOS is no more than 60,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature:  Date: 14.03.2018

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Abstract

The Internet has been serving as an effective marketing tool in tourism. It provides both the business and the customers with a valuable tool for information sharing, communication, and online purchasing. Photos posted along traveling are fast and up to date, and as they are available everywhere, and they have become the word of mouth of the digital age. Research accomplished throughout the last couple of decades has demonstrated that the photo is an essential concept for understanding the process of selection of a destination by tourists. They are easily recognised and remembered by customer than words. Photographs were also found to attract attention from a customer more than textual content when visiting web sites of online shops and they evoke feeling and generate desire for the associated products or places. However, there have been very limited attempt to assess visual content and visual quality of online photos. That is probably due to the limited background in photography among tourism researchers, and the inefficiency of manual assessment approach for large scale dataset such as the case of online hotel photos shared by travellers. As a result, prior works were unable to provide comprehensive understanding about traveler's perception and interests toward hotels, especially the differences between visual photo content and visual photo quality shared by different groups of travellers online. Aiming to overcome these barriers, the focus of this thesis is to introduce computational approaches to automatic photo content recognition and visual features extraction for automatic photo quality assessment from online hotel photos.

The first topic is on *Visual Photo Content Assessment*. The critical factor of successful business in the tourism has always been in careful planning and decision

making. Understanding why people travel and what makes them choose a specific hotel or accommodation as well as addressing their interests and needs is useful to tourism planning and marketing. Having a clear picture of customer preferences and their behaviour help business managers for the efficient planning process. Photographs are considered to be a serious part in determining the amount of significant customer variables, including destination choice, tourist behaviour, and product satisfaction. Thus, in order to be achieved more effective tourist destinations promotion, the tourism businesses have to assemble and market location photos that potential visitors will find attractive. Photo content analysis of the photographs taken by tourists plays an important role in better understanding the images of destinations held by tourists. Knowledge of affective images can aid hotel marketers to integrate their image positioning in the promotional themes aiming at potential customers. However, there were very limited attempts at tourism literature to assess the photo visual content recognition. In the past even simple photo recognition tasks could be solved quite difficult using manual approach, that was usually time-consuming and required human interaction. With the introduction of computer technology, researchers began using machine learning methods for automated visual content recognition where they performed pretty good with datasets of big size.

Aiming to address the above-mentioned shortcomings, this chapter analyses the visual content in online hotel photos using automated computer approach. Since in our experiment here we use large dataset, in order to improve the performance we employed a machine learning model trained from a large Convolutional neural networks (CNNs). CNNs has been successfully applied in various photo recognition systems, and they have the ability to process a relatively large amount of data without using much effort and a significant amount of power. A number of different experiments were conducted in order to validate the introduced method as well as identify customer's preferences based on visual photo content assessment. We explore the photo content differences between different groups of travellers to reveal their interests reflected in the captured photos.

The second topic is on *Visual Photo Quality Assessment*. Tourism businesses have long recognised the significance of promoting photos in order to create their brands in travellers' minds. One of the most important factors that hotel marketers have to take into consideration when advertising their business is the attractiveness of the photo, including good photograph quality. A better quality photograph become critical element in the tourism advertisement online as well contributes to the attractiveness and interest of their websites. However, there were very limited attempts in tourism literature to assess the photo visual quality, probably due to the large scale data and the limitation of manual analysis approach. It is necessary to access the photo quality for insight understanding about the tourist experience and their influence on viewer's perception, to support strategic decision making of Destination marketing organisation (DMO) such as marketing material development.

Aiming to address the above mentioned shortcomings, this chapter analyses the visual quality in online hotel photos using automated computer approach. We selected five visual features, which are helpful in reflecting the visual photo quality. A number of different experiments were conducted in order to validate the introduced visual quality features. We explore the photo quality differences between different groups of travellers to discover the photo influence on travellers decision making.

The introduced methods in this thesis are beneficial to researchers and hotel managers in better understanding customer experience and interest as well as for making appropriate decision making and business planning. These techniques also help hotel owners of selecting appropriate visual content for developing marketing materials, which better capture traveler's attention and generate positive feeling for customer toward hotel products and services. This thesis additionally provides a groundwork for visual data analysis of online photos, specifically in the tourism, which is at the moment the fastest growing industry in the world.

Keywords: Hotel Photos, Visual Features, Quality Assessment, Content Assessment, Social Media, Data Mining, Machine learning, Convolutional neural networks (CNNs).

Chapter 1

Introduction

Tourism as a business is the fastest-growing industry in the world over the past few decades with no signs of slowing down in recent times [152]. According to the World Tourism Organization (WTO), at the beginning of the 21st century, international tourism grew 7.4 percent, and it is expected until 2020, the number of people travelling internationally to be increased to around 1.6 billion [88]. Tourism creates a direct and indirect contribution to the local economy growth in a country as well as it increases the tax income and helps the exporting of local products [88]. A country can also benefit from the tourism by providing a quality service and improves the satisfaction of customers, therefore, can increase customer's loyalty and furthermore attracting new customers [152]. People travel to new places each day for a variety of reasons, for example, tourists travel to new locations for spending their holidays, others travel for business purposes, or travel can occur due to many other reasons. These people that are travelling new locations need place to stay over night along with many other facilities for more enjoyable stay. For that reason both hotel/accommodation and hospitality businesses are closely linked to the tourism industry. A comprehensive knowledge of tourists needs can aid the managers of these industries take an advantage

the market regarding strategic planning, marketing, and product development [205].

The tourism industry is dealing with a tremendous amount of data accumulation from their customers every day. Comprehensive analysis of customer's information is beneficial but challenging task helping tourism business such as hotels managers for effective knowledge of their customer's preferences and feelings towards certain accommodation or services that they offer. For instance, understanding what have motivated people to stayed to that specific hotel or actually what activities and services are preferred among which group of people or why they have considered traveling to that particular destination, etc. However, due to the absence of people's ability to handle with this huge amount of information in the database, previously there was a lack of analysing these existing gigantic data resources accurately. With the computer technology introduced these days, data mining has become much easier way for studying customer preference, due to its outstanding ability in extracting and discovering useful knowledge from large customer databases [8]. The fast growth of computer technology has also developed a significant amount of different tools and data mining algorithms that have been successfully implemented in various areas of the tourism industry. For example besides textual information, nowadays visual data has also the ability for extracting useful knowledge and hidden predictive information in tourism applications.

Research accomplished throughout the last couple of decades has demonstrated that the photo is an essential concept for understanding the process of selection of a destination by tourists [41, 4, 80, 55, 142]. They are easily recognised and remembered by customer than words [167, 211]. Photographs were found to attract attention from a customer more than textual content when visiting web sites of online shops [149].

On the other hand, the Internet has been serving as an effective marketing tool in tourism [18]. It provides both the business and the customers with a valuable tool for information sharing, communication and online purchasing. Photographs evoke feeling and generate desire for the associated products or places [127]. Travel photographs can be indicators reflecting personal emotions of the travellers. They also preform as memories that collect travel experience of the tourists. The photographer (in our case the tourist) is the 'source' from which the personal feelings form the travellers are expressed [20, 162, 163] through organising the authentic content. A beautiful photo of a clean room shared on hotel review web sites would implicitly generate the positive feeling for viewers about the room, while a photo of a dirty room would express otherwise. Pan et al. (2014) have discovered that natural resources portrayed in vivid visual photographs are more likely to enhance the effective image of the destination [136]. Moreover, it was found that the motivation to visit new places are impacted negatively by caused fear from advertisements representing risky nature attractions and individuals in risky vacation situations, therefore, these effects reduce travellers' intentions to visit a tourist destination [71].

Destination image is a widely studied topic in tourism, nevertheless, most of the researchers refer to measuring visitors' affective images of the destinations [5, 86, 172], and only limited studies are dedicated to the understanding of what photos or images will stimulate what type of affective feelings toward a destination [132, 216]. Just as tourism managers needs to know how the photograph affect tourists and what message will be created in tourist mind towards a specific location before they go there, it is also important to understand tourist's experience after their trip was taken, through analysing their post-visit photographs [31]. Those online travel photos

provide excellent sources for exploring travellers' perception about destinations and tourism products, which are useful to both potential travellers and the tourism and hotel industries.

1.1 Motivation

Various attempts have been made in analysing online photos to gain insights into traveller's perceptions [57, 176, 136, 69]. Nonetheless, the majority of research studies in the past were focused mainly on professional photos taken from the tourists [57, 151] because personal photographs could not be accessed easily and they had not widespread impact in comparison with professional books or magazines, such as 'National Geographic Magazine' [151]. But today's Internet provides a worldwide channel for the distribution of personal photographs, therefore, photographs posted in travel blogs can be easily used to understand the motivations and perceptions of tourists. In addition, current analysis solely relies on the subjective assessment of the researchers involved in the studies by viewing the sampled photos [176, 136, 69, 180]. Due to the limitation of manual analysis approach, prior works were unable to provide a comprehensive understanding of traveller's perception and interests toward hotels, especially the differences between photo content shared by different groups of travellers. Previous studies have also ignored the quality dimensions of photos [57, 136, 69], which are important in gaining insights into traveller' perception and experience.

The motivation of this thesis is presented using the following scenarios in analysing tourist behaviours from online hotel photos.

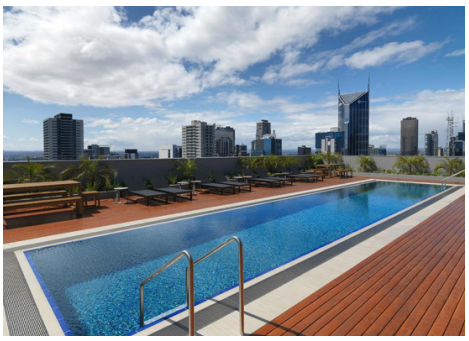
1.1.1 Exploring tourist interests based on Visual Content Recognition

Visual content captured in the photos can be considerate as visible representations of particular characteristics of different dimensions of the traveller experience, as for instance, the photo of the tourism destination, the specific location the traveller has been to and the events they have experienced [58]. Taking into consideration that a tourist takes photographs to memorise something that draws him or her attention, the tourist contributed photograph collection delivers essential information and knowledge of travellers' commitment and response to people and event at different places [21]. The photos provide excellent sources for exploring tourist interests, which are very useful to both potential travellers and the tourism/hotel industry. *It is beneficial for DMO to access the photo content to identify what tourists are interested in to tailor their product development and promotion strategy to improve tourist satisfaction.*

Visual content classification of photographs into different categories is a challenging and important problem nowadays [12]. Indexing and categorising the humungous data from travellers is very useful for discovering travellers interests as well as an efficient way for tracking customer behaviours. As an example, travellers who stay in the hotels can take photos of a *Dining Place*, their *Living Room*, *Bathroom* or maybe some other hotel facilities. Each of this photos could identify how the customers feel when they took that photograph. Figure 1.1 shows some sample photos taken from travellers in the hotels. For instance, a *Dining Place* could show a nice restaurant

where travellers prefer to eat (Figure 1.1a) or maybe a photo from *Living Room* (Figure 1.1c) or *Bathroom* (Figure 1.1d) could display some faults such as a dirty floor or broken sink. Photos of other Hotel Facilities could also show some nice beautiful, relaxing areas where travellers enjoy spending their leisure time during their stay in that hotel such as *Swimming Pool* (Figure 1.1b). Identifying such interests form traveller's photographs in tourism applications is beneficial for gaining better knowledge about costumers needs. Therefore, hotel managers could improve their business planning and decision making.

(a) Dining Place



(b) Swimming Pool

(c) Living Room

(d) Bathroom

Figure 1.1: Sample Photos from Traveller posted online

1.1.2 Understanding tourist photo experience based on Visual Quality

Besides the photo content, actual photo quality also plays a critical role in influencing customer's emotion and their decision making [169]. High-quality photographs are much easier to be remembered by the customers [128]. Low-quality photos could impact negatively the experience of potential travellers [169]. Website evaluation has been an emerged research topic in tourism literature, but it has not been focusing on the visual quality of photos on the websites [95]. This is probably due to the lack of methods for assessing the photo quality in tourism literature. Figure 1.2 shows some sample photos from traveller and management posted online. Both photos were taken by the management of the hotel (Figure 1.2b) and traveller (Figure 1.2a) in the same hotel with similar hotel room content. The photo in Figure 1.2b appears to evoke a positive feeling for the viewer due to its lightness and colourfulness, which is more attractive than the photo in Figure 1.2a. *It is thus necessary to access the photo quality for insight understanding about the tourist experience and their influence on viewer's perception, to support strategic decision making of DMO such as marketing material development.*

1.1.3 Summary

Previously mentioned examples before have demonstrateda few challenges in visual photo analysis in the tourism industry, particularly in the hotel businesses. Hotel managers and researchers have a long aspiration for understanding the needs of their

(a) Traveller (b) Management

Figure 1.2: Sample Photos from Traveller and Management posted online

customers as well as tourists' decision-making process in order to manage their businesses more effectively. Unfortunately, tourism researcher faces some difficulty in analysing visual data, due to the present tools and techniques that are not capable of performing the analysis tasks productively. Very limited tools and techniques support the development of tourism applications analysing visual photo content. This is probably due to the current approaches to photo recognition which are either subjective and time-consuming or lacking efficiency and make a significant use of computer power to solve even a simple task. For visual quality analysis, there is lack of methods for assessing the photo quality in tourism literature along with the large scale data and the limitation of manual analysis approach. By filling these gaps mentioned above, we can better support hotel managers in visual photo data analysis from travellers. Therefore hotel owners can be able to achieve a deeper understanding of their customer's experiences and interests. As a consequence hotel industries can develop better appearance according to the customer's requirements as well as achieve more significant strategic planning and decision making.

1.2 Research Objectives

The goal of this thesis is ***to introduce new tools and techniques for automatic evaluation of visual photo content and visual photo quality into tourism context***. The methods are beneficial to researchers and practitioners in analyzing large scale online visual data and at the same time support decision making and business planning in tourism and hotel industry.

The major shortcoming of existing works in tourism and hospitality literature is that the assessment of photo content and analysis of photo quality were mainly carried out manually. This approach is time-consuming and impractical for large photo collection shared by tourist on social media platforms. Researcher and tourism managers are still unable to obtain a comprehensive understanding about tourist perceptions and interests for better their strategic planning and decision making. This research aims to address the shortcoming by adopting advanced techniques computer vision and image processing. Due to the limited scope of this research, we only focus on a specific domain in tourism and hospitality, the hotel photos, to evaluate our approach and demonstrate their practical application capability. To achieve this goal, the following research objectives are the targeted of this thesis:

- To introduce techniques for automatic recognition of photo content that support the analysis of travellers' interests of hotels.
- To introduce techniques for extracting photo features which can represent the visual quality of hotel photos.

- To evaluate the proposed techniques on visual photo analysis in tourism applications.

The methods and findings in this study provide hotel managers with better understanding about traveler's experience and interests. Hotel owners can selecting appropriate visual content for developing marketing materials, which better capture traveler's attention and generate positive feeling for customer toward hotel products and services.

1.3 Research Problems

In the past, a traditional method using people with survey techniques were used for visual photo content analysis. Unfortunately, those conventional approaches were time-consuming and inefficient when it comes to a large number of photos. With the fast development of computer technology, a whole lot new opportunities for visual content assessment were open. Researchers began using machine learning methods for automated visual content recognition where they performed pretty good with datasets of small size. This was not a case with much bigger datasets where these approaches were lacking efficiency, and they made a significant use of computer power to solve the task. Our research problems in using visual photo content analysis of online hotel photos are presented as follows:

- *How to find an efficient model and better machine learning techniques for automated evaluation of visual content recognition using large data from online hotel photos?*

- *How can the model efficiently be implemented into our analysis of hotel photos?*

The human eye can easily recognise and differentiate low-quality from high-quality photographs, and they have got ability subjectively access the quality of a distorted photo without examining the original photograph as a reference. The problem of this subjective approach using people to determine the quality of a photo, is inefficient when it comes across large dataset such as ours that we use here in this thesis. For that reason, is an essential developing a computational automatic way of objectively recognising the visual photo quality. Considering that photographs can be taken at different parts of the day such as day time and night time, a photograph taken at night time does not mean being of low quality despite lower brightness. For fair comparison we need separately analyse those photographs. Our research problems in using visual photo quality analysis of online hotel photos are presented as follows:

- *How to effectively identify the right features represent the visual quality of hotel photos?*
- *What techniques can be used to separate the day time from nigh time photos?*

1.4 Approach

According to the problems described in above section, the following approaches are presented in this thesis:

Automatic Visual Recognition of Photo Content: Current approaches to objective photo content recognition are inefficient when it comes to photo content assessment on large datasets. Various machine learning methods have been proposed lately, but they make a significant use of computer energy, and they are

unable to handle complex tasks with big visual data. Thus, to delivery efficiency in our experiment in this thesis, we need to use more robust models and better machine learning techniques for preventing overfitting. In order to analysis the visual photo content from online hotel photos, we adopted a machine learning model trained from one of the biggest Convolutional neural networks (CNNs) to date. CNNs has been successfully applied in various photo recognition systems, and they have the ability to process a relatively large amount of data without using much effort and a significant amount of power. Later, our research reveals the interest differences between different groups of travellers from online hotel photos.

Extracting Visual Photo Quality Features: This thesis adopts visual features for automatic visual photo quality assessment from online hotel photos. We selected and applied five representative features to our datasets, which are helpful in reflecting the visual photo quality such as *Brightness*, *Colourfulness*, *Contrast*, *Sharpness* and *Noisiness*. Furthermore, we analysed the perception differences between different groups of travellers from photo quality perspectives. Taking into consideration that the photos can be taken at both day time and night time, a photo taken at night time is not necessarily being of low quality despite lower brightness. For fair comparisons, we classify the photo collection into two classes, *Day* and *Night* using Support Vector Machine (SVM) to compare separately in the subsequent experiments.

Hotel Photo Applications: The developed methods on visual photo analysis were verified in real tourism applications. Hotel industry was represented in our experiment, mainly hotels in Melbourne. A significant amount of online hotel

data was used for our examination of this visual photo study. The challenges in this applications are addressed with the following aims: to explore tourist interested and discovering travellers experience when travelling to the hotels, to explore how photo quality influence travellers decision making of choosing a specific hotel/accommodation. The outcome of the analysis will provide hotel managers with a better understanding about their customer's needs and also help them build more efficient products and services, engage more customers and create stronger influence on their hotel brands.

1.5 Thesis Outline

This chapter pointed out the organisational structure of this thesis as well as identified our research direction, tools and techniques applied. It also explains the motivations, goals and research gaps of this thesis. The rest of the thesis is organised as following:

Chapter 2 provides an overview of previous related efforts analysing visual photo content and visual photo quality assessment in tourism and hotel industries as well as we look at some previous photo assessment in computer science. We highlight some of the present and appearing problems of visual data analysis in the tourism industry, which are going to be solved by introducing new computational techniques and tools and then applied to the tourism applications in later chapters of this thesis.

The main contributions of this thesis are described in Chapters 3 and 4, in accordance with the determined objectives above.

Chapter 3 introduces out approach to visual photo content assessment based on Convolutional neural networks (CNNs). Details about how the model was trained and why we choose this model are first represented, which is then followed by how we

implemented it and better organised the final output labels. At the end, we compare visual photo content differences between different groups of travellers.

Chapter 4 presents out approach to photo quality assessment based on visual features. Details about five visual features are first represented, which is then followed by an analysis of some samples photos and their visual features and then compare visual photo quality differences between different groups of travellers.

Chapter 5 concludes the thesis by summarising both theoretical and practical contributions and addressing some possible future research.

Chapter 2

Literature Review

More recently, the online platforms have been allowing virtual advertisement experiences (panoramic viewings, interactive animations, and pictures) directly impacting the tourist. These virtual experiences have as much as or more meaning than the information(s) he or she receives from friends, relatives or travel agencies [28]. The website is known as a digital, one to many media that it can be employed to deliver the first move of getting customer attention, therefore, encourage eWOM (word-of-mouth) between tourists. Allowing loyal customers to share their holiday photos equally on the business's website as well as their own websites such as blogs and wikis supports eWOM. These are improving tourist satisfaction throughout brand enhancement, traveller issues solution, revealing what travellers tell good or bad about their experiences, examining business-minded approaches, and observing business reputation and image. By providing reinforcing photos and opinions are helping potential visitors seeking information easily as well as helps to encourage and inspiriting good eWOM, and at the same time the outcome would result in improved business activity [107]. An efficient website is a powerful tool for the company to strengthen its relationship with customers and secure larger market segment [95]. A well-designed

website with appropriate visual content such as photographs would support hoteliers to get better customer recognition of its products [108], and build the customer loyalty [3].

Taking photo is an essential part of trip activities for most travellers [40]. The photos taken by travellers reflect and inform destination images [193]. Dobni & Zinkhan (1990) refer to 'image' as the sum of beliefs, ideas, or an overall influence that a person has of particular product or place. The image of a destination is formed through the process of collecting information about the destination via different information sources, such as promotion, marketing material, online reviews and travel photos [185]. Kwortnik & Ross (2007) showed that positive emotions could be stimulated in response to imagery and provide a mental experience of a trip before the actual one take place. Ert et al. (2016) found that travellers tend to judge host's trust-worthiness based on photos posted online. The visual content is robust and has an additive effect on trust building. Researchers have acknowledged that image has cognitive and affective components [177], which has influenced on traveller's perception. A number of different studies have been undertaken in the last few decades, analysing photos in order to discover valuable information and transform it into useful knowledge.

For the purpose of demonstrating the background of this research, this chapter is dedicated to a comprehensive review of literature associated with existing work in photo analysis in tourism applications. We identify their current methods used for photo analysis as well as summarise their findings. The limitation of the prior works is also highlighted. Firstly, Section 2.1 describes our approach for conducting the literature review, and then Section 2.2 presents the categorisation framework of

different categories used in our review of photo analysis in tourism. Section 2.3 reviews existing approaches in photo assessment in different tourism applications and Section 2.4 looks at some existing photo processing techniques in computer science. In the last Section 2.5 we summarise all the existing findings as well as their limitations.

2.1 Literature Review Methodology

This literature review analyses research articles that were published mainly by tourism and hospitality journals, from 2006 to 2016. Due to the fact that there is not a particular list of research journals in this area, we are focusing on reviewing publications in top best journal articles according to specific lists of well-known journal rankings [126, 154]. Table 2.1 presents the journal names included in this review. The majority of these journals are ranked Q1/Q2 according to SCImago Journal & Country Rank 2016 (SJR ranking 2016), which is a publicly available portal that contains the journals and country scientific indicators established from the materials included in the Scopus database (Elsevier B.V.) [1]. We have studied the content of these research articles in order to organise the research topics and address the photo assessment techniques and tools used in relation to visual content and quality applications in the tourism, which are presented in the subsequent section. After reviewing journal articles in the tourism literature, we also searched for articles in computer science to see potential methods for visual data analysis. These journals are excluded from our list in Table 2.1.

Table 2.1: Journals included in this review

Journal Name	**SJR Ranking 2016**
1. Anatolia	Q2
2. Annals of Tourism Research	Q1
3. Cornell Hospitality Quarterly	Q1
4. International Journal of Contemporary Hospitality Management	Q1
5. International Journal of Tourism Research	Q1
6. Journal of Hospitality and Tourism Technology	Q1
7. Journal of Leisure Research	Q2
8. Journal of Tourism and Cultural Change	Q2
9. Journal of Travel and Tourism Marketing	Q1
10. Journal of Travel Research	Q1
11. Journal of Vacation Marketing	Q2
12. Leisure Studies	Q1
13. Tourism Geographies	Q1
14. Tourism Management	Q1
15. Tourist Studies	Q2

2.2 Categorisation Framework

Since this thesis here analyses the visual content and visual quality from online hotel photos, there are no existing categorisation frameworks for this topic. Our literature review is categorised based upon examination of content analysis of articles and inclusive evaluation of the topics, tools, and methodologies from the journals listed above in Table 2.1. We introduced the following five categories in order to achieve simple and convenient presentation in photo analysis applications in tourism:

- Photo Assessment in Tourism Applications using traditional photographs
- Photo Analysis in Tourism Applications using online photos

- Visual Photo Content Assessment in Tourism Applications
- Visual Photo Quality Assessment in Tourism Applications
- Photo Assessment in Hotel Applications

The aim of these five aspects mentioned above is to investigate different dimensions of photo analysis in tourism applications, as well as create a deeper understanding of various approaches in photo content and quality assessments that have been done before.

More about each of the previously proposed categories is described briefly in the subsequent sections below.

Photo Analysis in Tourism Categories

Considering that our topic is about exploring costumers interests, behaviours and experience when they travel and stay in the hotels using the visual data such as online photographs posted from the travellers along with their trip, in section 2.3 we only focus on studies that bring more knowledge about different approaches in photo analysis in various applications in tourism. Each of the previously mentioned categorises are going to help get better knowledge about how photos can affect travellers as well as understand the techniques applied along with the limitations they are facing. The details of the five categories in photo analysis in tourism are provided as follows:

Photo Assessment in Tourism Applications using traditional photographs:

The aim of this category is on photos analysis, exploring different research articles particularly in the tourism. These studies show various findings where

visual data such as traditional photographs in brochures, postcards or generated by tourists themselves have been used in different tourism applications. For example, Jenkins (2003), shows that apart photographs employed in the brochures and other marketing materials inspire the tourists to visit specific destination but also that those photos are encouraging them taking photographs and become a main aim of interest for the traveller [79]. Furthermore, Buchmann & Frost (2011) have found that a photo of a beautiful landscape evoke feeling of high chances to visit that place [17], but on the other hand, Hem et al. (2008) has discovered that the reason to visit a place is negatively influenced by caused fear from advertisements illustrating unsafe nature attractions and tourists in insecure vacation circumstances. Therefore, these consequences scale down people's intentions to visit a tourist location [71].

Photo Analysis in Tourism Applications using online photos: The primary focus of this category is on visual data analysis more specifically from online photos. We looked at various attempts in tourism applications used these online digital traveller's photographs in order to discover useful knowledge. For instance, Kwok & Yu (2013) found that photos receive more likes and comments than link and video on hotel's Facebook fun page [93]. Another approach to content analysis was adopted in a case study of Japan [173]. They found that the most dominant theme among DMO photos is modern architecture, whereas, the most popular theme among travellers photos onto photo sharing site Pinterest is natural and landscape.

Visual Photo Content Assessment in Tourism Applications: This category focuses on photo content analysis exploring different approaches from various research articles in tourism. We looked at prior and current techniques and tools used in photo content analysis in tourism applications. A shortcoming of such techniques are also listed. For example, Fairweather & Swaffield (2001) employed the Q sort technique to explore travellers' journey experiences based on photos provided by 30 researchers [48]. Moreover, Naoi et al. (2006) used repertory grid analysis method in order to explore the correlations between travellers and their thoughts of a historical region in Germany [130]. On the other hand, Jenkins (2003) applied a thorough content analysis of photos included in 17 brochures using visitor employed photography (VEP) technique, hence, encouraging backpacker travellers in Canada to visit Australia [79].

Visual Photo Quality Assessment in Tourism Applications: The aim of this category is on photo quality analysis examining some previously done studies on this topic. We reviewed different methods and tools on photo quality assessment that has been done in various applications including tourism. Limitations of such techniques are also listed. For example, Savakis et al. (2000) study examines the image quality using eleven participants [156]. Additionally, the prior research examines eleven people and refers to eye movement technique during the process of best photos selection [60]. A few prior attempts in tourism have mainly adopted the subjective methods to evaluate photos on websites [81, 179, 46], which is slow and inconvenient for large scale analysis [188].

Photo Assessment in Hotel Applications: The focus of this category is on photo analysis, exploring different research articles particularly in hotels applications.

These studies demonstrate various approaches where hotel's photographs have been studied in different cases. Such review is helpful in order to get to know about different ways of prior hotel photo assessment. As an example, Jeong & Choi (2005) measures the influence of photo presentations on a hotel website to customers' attitudes and intentions, based on the content analysis [81]. Stringam & Jr (2010) focus on exploring the impression of users about the visual content on hotel websites such as photos, colour and other information [179]. In addition, Kuo et al. (2015) aims to explore the impression of misleading pictures on hotels websites based on customers' emotional feedbacks, brand trust as well as negative word-of-mouth (WOM) intention [92]. Countryman & Jang (2006) study examines the atmospheric elements of colour, lighting, layout, style using photographs of a hotel lobby [30].

2.3 Photo Analysis in Tourism

2.3.1 Photo Assessment in Tourism Applications using traditional photographs

Researchers have recognised the ability for visual data to enhance the research process. In fact, numerous research analyses have been commenced that make use of this visual data find in various holiday brochures [34, 146, 196] and on postcards [2, 45, 124]. A research study analysing travel brochures shows that 75% of their content are photographs [39]. Photos have also been broadly used as encouragement in the process of evoking replies from respondents in interviews, market surveys and

questionnaires, for instance in researching destination images [142]. Several studies have been announced that use visual data that has been created by travellers themselves [58].

The study The Tourist Gaze by Urry (1990) explores the intimate correlation among photography as a travellers routine and tourism as a production system [193]. Jenkins (2003), meantime, clarifies not only that these visual pictures stimulate the travellers' visit to a specific location but at the same time that taking photos becomes a primary focus of activity for the travellers [79]. Furthermore, Larsen (2005), points out photos all together create and show instances of family closeness [94], whereas Groves & Timothy (2013) emphasise their significance in a social connection by observing that 82% of the photographs analysed out of a group of students included another group members [66]. Therefore, Edensor (2000) argues travellers employ photography as a official form in order to capture the relationship between each other, the locations and the different cultures [44]. Another study by Schmallegger et al. (2010) notes that even though a greater amount of tourist photos tend to enlarge current Destination Marketing Organisations (DMO) images, other photos may increase further the desired DMO image to illustrate a different understanding or impression about the destination [160]. Their study of the Flinders Ranges in Australia discovered that DMO photos mainly involved people in the wilderness, whereas personal photos emphasised loneliness, isolation, and being in the middle of nowhere, an image that was inimical with that desired of the DMO.

It can certainly be said that postcards play an important role in the creation and illustration of destination images, such as impacting traveller expectations of a place, their relationship with it, and their experience assessment of the destination

after their trip has been taken. Quite a few studies have been introduced in the past analysing these postcards. For instance, Pritchard and Morgan (2003) have focused on analysis based on twelve postcards with photographs of Wales. Their study aimed to identify which photographs travellers prefer and which one do not. The findings of this study suggested a remapping in which the capital city of Weals, Cardiff is shown as the modern metropolitan hub of the country, but on the other hand, other places are illustrated as pure antiques and historical sites [147]. Similarly, a study by Marwick (2001) of postcards from Malta has showed how the exotic photos of the destination has been replaced in the past with more sophisticated set of photographs where Malta is represented not only as an exotic tourist destination but more into the behind the scenes realities of life on the island [124].

Furthermore, other studies have examined the importance of postcards in cultural representation. For example, Albers and James (1988) used a sample of postcards from a period of more than 35 years time in order to study the correlations among tourism, ethnicity, and photography [2]. Edwards (1996) has investigated how the representation of truism photography has shaped the cultural identities using a museum collection of postcards. In the meantime, Mamiya (1992) has examined the Hawaiian culture and how it has been illustrated and changed by postcards [122]. Burns (2004) has explored the visual representation of tourism, cultural imagery and colonial discourses using six postcards from North Africa and the Eastern Mediterranean [19]. A few such studies have actually continued to explore the importance of postcards in supporting tourist gaze, either theoretically or empirically. An exceptional is the study from Waitt and Head (2002) where the primary focus has continue to be exploring 'frontier myth' of the Australian outback and the importance of postcards for

that purpose [201]. Concentrating specifically on postcards from the Kimberley, this study has shown how postcards have achieve different categorical comparison such as between society and nature, human and animal and civilised and wild, therefore, creating an image of a place that is appropriate to being sold to travellers. Waitt and Head (2002, p. 324) thus link postcards directly to the tourist gaze, arguing that they "give shape to tourist practices, helping to guide the tourist gaze . . . As a guide, postcards instruct tourists how and what to see, in terms of where and when to gaze, and how the 'capture' a particular site."

Molina and Esteban (2006) have studied the importance of brochures and how they impact towards tourist's destination choice. The analysis of their study was based on data collected from travellers in Madrid, Spain. To accomplish this study, a survey approach was used where adult participants with 18 years and above have taken place. All participants were asked to analyse a series of brochures that were written in Spanish language and then give their opinion relating to the brochure's visual appearance. Several factors were taken into consideration when the analysis was conducted such as the size of the location, internal or coastal destination, geographical location (Northern, Central, Southern) and the origin of the brochure (Government, Administrative, Unknown). The brochures form eight different cities in Spain were explored including Toledo, Madrid, Cordoba, Sevilla, Cuenca, Barcelona and Santander. The findings have established a prototype of advantages of brochures for satisfying customers necessities following the suggestions for better brochures content and design [128]. Additionally, Wicks and Schuett (1993) have explored a group of potential travellers and their request to a particular location form six brochures. Their study has discovered the correlation among travellers requests and their probability

to visit that place [204]. On the other hand, Getz and Sailor (1993) have examined the visual design of destination brochures according to two aspects: attractiveness and usefulness. This study pointed out how the visual design of a brochure plays an important role in creating an image of the tourist destination as well as stimulus trip motivation and helps destination choice [59].

It has been noted that tourists have various reasons and stimulus for taking photos during their holidays, trips or visiting places. Chalfen (1979), for instance, believes that the majority of travellers taking photographs in order to document their real experience [23]. It is suggested that this is the reason that most traveller photographs include a set of photos that already seem in brochures, postcards or other tourist promotional materials [79, 195] as they confirm the sense of 'being there' at signed places [118]. Most photos also involve friends or family members because travellers engage significant others with particular places to create their wish for closeness, integrity and intimacy [68], especially from a Chinese cultural perspective. Robinson and Picard (2009) also indicate that taking photographs is a sense of playfulness, especially for family or group tourists [151]. Thus taking photographs is not only a way of bringing the outside world home by tourists [151], but also a form of collecting personal and family memories [194, 195]. Therefore, such analysis helps to understand tourist behaviour, if only at the level of following their itineraries. It has been argued that the stimulus for taking photos and the content of these photos play an essential role in the model society and visual culture [151].

Buchmann & Frost (2011) have found that a photo of a beautiful landscape evoke feeling of high chances to visit that place [17]. That was a case in the famous movies based on The Lord of the Rings novel, by J.R.R. Tolkien where the images in the movie

have provided viewers with an alternative image of New Zealand in the sense that the landscape is overlaid with fantasy. These images were used in the official '100% Pure' tourism campaign in New Zealand because of the feelings given to the travellers as a glamorous, remote and dreamy country that is pure, green, inspiring and yet safe [17]. Moreover, it was discovered that the desire to visit a tourist destination is negatively impacted by caused fear form advertisements illustrating unsafe nature attractions and tourists in insecure vacation circumstances, therefore, these consequences scale down people's intentions to visit a tourist location [71].

Photographic approaches provide researchers to study the relationships of real-world variables and how they influence people [65]. What is clear yet, is that we are only at the beginning of understanding this phenomenon. Therefore, Tussyadiah & Fesenmaier (2009) recommend the necessity for more studies to improve knowledge how the promotion of digital media technology influences tourism experiences [191]. Brochures have traditionally been the most widespread way of advertising tourism products visually, however, the internet has most certainly become an increasingly popular communication channel [29]. Although destination image is an extensively studied topic in tourism [136], limited studies are devoted to examining the online travel photos for better understanding about the destination image perceived by travellers.

2.3.2 Photo Analysis in Tourism Applications using online photos

Limited attempts have been made to analyse online photos for insights into traveller's perceptions about the destination. For instances, Pan et al. (2014) performed

a content analysis of travel photos to uncover the connection among motivation, image dimensions and affective qualities of places [136]. Garrod (2009) combined content analysis and quantitative statistical techniques to discover the correlation among tourism destination representation and traveller photography [57]. Additionally, Boley et al. (2013) made a comparison between trip photos to non-trip photos posted online regarding travellers souvenir buying behaviours [11]. On the other hand, Stepchenkova & Zhan (2013) performed a comparative photo content analysis between travellers and marketers in Peru and revealed some differences in several dimensions [176]. It can be clearly said that the increased amount of private travel blogs and other online media played an important role in promoting the tourist destination, by posting and reviewing exiting photos on the web [64, 159]. For example, that was a case of a Taiwanese traveller who traveled to Aegean Sea. He decided to post his vacation photos on a famous website, therefore, in a period of several days the post has reached more then 60,000 visits online. This website unexpectedly supported advertising tourism in Greece and also helped the truism industry there to get into the Taiwanese market for the first time [105]. Moreover, Lo et al. (2011) examined how Hong Kong citizens employed photo-sharing technologies and how this has impacted the search for information and the choice of the destination. Their study has shown that about 89% of the tourists take photos and that around 41% of them are posted online by the travellers. The most popular media used for this purpose were the social network sites, personal blogs, inserting messaging applications as well as the online photo albums. Furthermore, this study found that most tourist who post these photos online are younger, better educated, and earn more money than those travellers who do not upload their photos on the web. It was also found that these

tourist use more than one platform to spread their photos online [111].

Pearce et al. (2015) have sought to understand how tourists represent a key landscape using their online photographs. Chinese tourists and Australia's Great Ocean Road tourism attraction, a leading international road trip, are of particular interest in this study [137]. In detail, this study aims to categorise the Chinese tourists' online visual representations of this iconic landscape. This study also seeks to examine the photo categories in terms of the main kinds of social representations for this evolving Chinese market. The nine themes identified in the coding process capture these common photos and reveal several points of broad interest pertinent to the overall theme of destination image construction. First, there is an imprecise matching between the destination marketing organisation's major presentation of the driving route and the way tourists present their photographic record. The Chinese tourists certainly use the Great Ocean Road experience to view nature and Australian wildlife, as promoted by Tourism Victoria, but they also use it much more than is emphasised in the publicity material to observe and interact with the society they visit. The photographs of everyday experiences have a solid set of percentages across the sub-themes in all the relevant categories. For example, the Chinese tourists take and post online photographs of petrol stations, people walking their dogs, civic signs, flowers, cottage gardens, local car models, free barbecue sites, local food, restaurant prices and menus, shopping bargains, and sheep and cows in paddocks. The findings reinforce the view that tourists' views of destinations and particularly their online reporting of images may be portraying everyday or mundane perspectives on tourism settings.

A different type of study on social network sites has analysed how subjective

feedbacks differ in terms of personal characteristics and experiences. Gender has often been recognised as an effective element in travel-related information searches on the web [85]. Hum et al. (2011) have analysed gender characters in photographs from Facebook based on a comparison between the content of the photograph and volume of profile photos [73]. At the same time, Kwok & Yu (2013) discovered that photos gain more likes and comments than link and video on hotel's Facebook fan pages, and conversational messages get more attention than advertisements for sale and marketing. Additionally, online articles including photos or environmental concerns have more chances to be reposted by other people [93]. More specifically, photos taken by travellers and uploaded to Flickr, an online photos sharing platform, are more likely to contain daily activities, plants, domesticated animals and food than photos taken by DMO. On the other hand, DMOs tend to include traditional clothing, art objects, festivals and ritual into their photos for marketing purposes. A similar approach to content analysis was adopted in a case study of Japan [173]. They found that the most dominant theme among DMO photos is modern architecture, whereas, the most popular theme among travellers photos onto photo sharing site Pinterest is natural and landscape. A study by Kim et al. (2014) has explored the variances among searching and surfing online based on photographs from Facebook pages. For this research experiment, Kim et al. (2014) have used two Facebook pages, San Francisco (www.facebook.com/SF) and Sacramento (www.facebook.com/cityofsacramento). The reason for choosing these two Facebook pages rather than other was in the fact that these cities have so much in common including the appearance on the photographs. The analysis was conducted with 54 participants that were mainly hospitality management undergraduate students. They

were asked to view photos and choose if they have or have not seen that photos previously in the experiment. After employing a visual-recognition test, the results of this research illustrated that participants identified the photographs they got from searching more accurately than the photographs they got from surfing on destination Facebook pages [87].

It was found that tourists' online photographic posts are arguably worthy of study and research interest because they represent a cutting edge in this shared, image-based communication about visited places [148]. There are five features of online photographs which underpin their power to influence others. First, photographic stimuli are easier to recall and remember than text-based information [211]. Second, O'Connor et al. (2011) noted that photographs are quickly scanned and accessed and, if liked, prompt viewer reflection [134]. Arguably, videos also stimulate and direct the attention of blog readers but they do require a little more effort to view and assimilate. Third, photographs are seen as trustworthy and highly credible. A fourth feature of photographs on the blog sites is that they are recognised as being up to date. The blog postings are date-stamped and so the viewer can check the currency of the images. This feature supports the credibility and immediacy of the photograph as an influence on tourism destination image formation. A fifth feature of online photographs, recognised by Wang and Fesenmaier (2004), is their simple hedonic value [202].

In the existing works, the analysis has been carried out mainly using manual approach and focused on the photo content in general, but limited attempts have been done in hotel's photo content analysis specifically. Furthermore, only a very few attempts were made to directly assess the quality of the photos despite its vital role

in influencing customer's emotion and their decision making [50, 169].

2.3.3 Visual Photo Content Assessment in Tourism Applications

Content analysis was firstly introduced in the textual material before it expanded to visual material. Lately, content analysis has taken place into photographs where determining the content of a photo has gained extensive attention by researchers. For example, Lutz & Collins (1993) used content analysis to examine nearly 600 National Geographic photographs over a period of almost thirty years [117]. Furthermore, Feighery (2009) examined photos from stock collections used by Official Tourism Organisations in the UK [53]. Chalfen (1979) denoted that besides the importance of photography for determining the tourist behaviour, its role in tourism has never been seriously studied [23]. However, over a period of the last thirty plus years, this situation has drastically changed, and now there is a significant amount of research available on the use of visual data such as photographs in tourism. Many researchers have their attention on the visual photos find in travel materials such as brochures and postcards [42, 43, 74, 79, 121, 146, 158, 168].

The applications based on visual content techniques in tourism research has become widely popular nowadays. For instance, Fairweather & Swaffield (2001) applied the Q sort method to examine travellers' destination experiences based on photographs provided by 30 researchers [48]. A Q sort is a traditional method almost identical to a cluster analysis used in photo content analysis, where people are usually involved in sorting the received feedbacks and creating constant categories based on expert consensus [59]. In their study, Fairweather & Swaffield (2001) advised photo

samples should be broadly employed in the cognitive research of destination landscape [48]. Another research study examined the visitors' and locals' experiences in Rotorua, New Zealand. The research shows how experiences differ between various groups. Photos were Q sorted by a nonrandom sample of locals and both overseas and New Zealand. The findings of this study indicate that Q sort with photos is a practical research technique which helps our knowledge of destination image and provides results that have significance for the present theoretical debate on the nature of tourist [49]. Following the previous studies above, another research has also used Q sorted method to sort photographs into different categories. This study took place in Quebec City, Canada where a group of student tourists travelled in June 1999. Every student was asked to choose 10 photos from between he/she took during their trip there that illustrate the most important aspects of the trip. Everyone reviewed their own selected photographs and then gave an explanation why each photo was important to them from the perspective of trip characteristics. This grouping analysis helped to get knowledge about the trip regarding the experience the students had on this organised tour [66].

Repertory grid is another technique used to analyse photographs visual content. Naoi et al. (2006) used repertory grid analysis to examine the correlations among tourists and their point of view about a historical location in Germany [130]. Matteucci (2013) collected 18 photos of flamenco dancing in Seville, Spain and employed repertory grid technique to study travellers' experiences with flamenco throughout their visits [125]. Botterill & Crompton (1987, 1996) and Botterill (1988, 1989) have combined the use of repertory grid method with visual photos using personal holiday snapshots and brochure photos in order to investigated tourist experiences based on

personal tourists viewpoint [15, 16, 13, 14].

Another research studies have applied a method called Visitor Employed Photography (VEP) to collect, analyse, and understand photos taken by travellers [56, 120]. This VEP approach distinguish with that researchers usually provide tourists with cameras, therefore, they are asked to take a specific number of photographs of certain locations or attractions [69]. Moreover, this technique uses the visual records of what mostly attracts tourists attention and in that way compared to photos presently used in promotional efforts [120]. In the early stage, VEP technique was employed such as practical research method by Cherem & Traweek at the beginning of the 1970s. Then it evolved into a technique for managing a wilderness area developed by Cherem & Driver (1983) and Chenoweth (1984) [27, 26, 25]. Various applications have been used this method ever since, such as in outdoor experiences studies, landscape preferences analysis, community planning as well as in different tourism applications [32, 112, 131, 133, 161, 175, 186, 209]. A comprehensive photo content analysis employing VEP method in 17 brochures was conducted by Jenkins (2013) whose results encouraged backpackers travellers from Canadian to visit Australia [79]. Jenkins (2013) commence 30 interviews that were semi-structured and additionally managed a one-on-one questionnaire with a further 90 backpackers that were travelling to and in Australia. The reason Jenkins (2013) has focused on this kind of study was to discover travellers behaviours, preferences and practices that were relate to their travel photography. In another research that involved the Welsh seaside resort of Aberystwyth appearance, Garrod (2009) had its evaluation applying the VEP technique in photos of visitors and pictures find in the city postcards. He found that the two instances of the photos had similarities regarding the overall photo composition

as well as the attractions and the locations taken in the photos [57]. Furthermore, a comparison of the photos of residents and visitors of Aberystwyth was evaluated by the same author Garrod (2008) in this study [56]. The outcome showed that the two of them had very similar way of 'reading' the destination. On the other hand, MacKay & Couldwell (2004) made a comparison of photographs of a national historic place that was in the region of Saskatchewan in Canada. This research was obtained by using the VEP method, with photos used in a promotional effort at that time [120].

In addition to the above mentioned methods for visual content analysis, different research approaches have also been done. For instance, a study by Vespestad, M. K. (2010) has examined the content analysis of nature-based tourism experiences in Norway. A total of 188 pictures from the websites and the two brochures formed the basis for analysis. The photographs in the advertising material were divided into four main units of analysis: picture heading of the front page of the website; front page of the website; front page of the brochure, and overall content of brochure. Front pages of the brochures were analysed separately as they make up the first impression. The promotion material addressed in each of the two markets is analysed separately for each unit of analysis, resulting in eight units of analysis. Pictures without landscape or natural surroundings were not included in the analysis, as they were irrelevant to the research question. Pictures were transcribed, indicators identified, and concepts derived from the indicators. Influenced by theoretical implications, categories were constructed making up the main differences in the content of the promotional material. The findings has showed that concerning landscapes pictured, coastal landscape is the most frequently occurring in all units of analysis, followed by the mountainous

landscape. Natural colours were most dominant, especially blue and green, supporting freshness and cleanness as values of Norwegian nature [200]. Similarly, Pollock (1995) has pointed out a few key changes that have been addressed between most important traditional media in tourism such as brochures and printed pamphlets and online media, affected by the increased amount of internet usage. This study has found that the content of the traditional media such as brochures and pamphlets or travel guides is based mostly on photos with texts from the tourism place. On the other hand, that is not a case with electronic media, where the content is mainly based on dynamic photos, animations, sound effect and validated source of pieces of information that are up to date and often updated in real time [145]. Greaves and Skinner (2010) have examined online brochures and leaflet through a content analysis. In their study they have explored approximately 400 online brochures from across the world focusing on the photos on brochures' first pages and front covers. The findings of the study pointed out that the most frequent features find were Landscapes, Weather, Culture and History, Services, Entertainment and Nightlife, Sports, Relaxation, Adventure and Nearness [62].

Photo visual content assessment is an important but challenging task for researchers and tourism managers, and it provides excellent sources for exploring tourist interests, which are very useful to both potential travellers and the tourism/hotel industry. Even though there were a lot of studies about photo visual content assessment in the tourism before, they solely rely on manual analysis approach focused only on photos in tourism in general, but no attempts have been made to examine their performance in applications to hotel travel photos specifically.

2.3.4 Visual Photo Quality Assessment in Tourism Applications

Photo quality is perceptual by nature, which makes it hard to measure in a standardised way [114]. The definition of photo quality also varied in different domains. Some disturbances in holiday photos would be acceptable, but that is not the case for X-ray images in medical applications. In the context of travel photos in tourism and hospitality, we refer to photo quality in term of their aesthetic beauty [114]. High-quality photos are pleasing to human eyes and may promote the positive feeling for viewers.

Techniques for assessing photo quality can be classified into subjective and objective methods [188]. The former studies involves human beings to evaluate the quality of the photos base on the judgement of individuals. For example, Savakis et al. (2000) study examines the image quality using eleven participants [156]. All participants were questioned to give rank to the photos and explained their own reason for each photo demand. The outcome revealed that each photo demand was evaluated regarding low-level features (e.g. lighting, colourfulness, contrast, sharpness) and high-level features (e.g. people, composition, subject). Another prior study was conducted to investigate the eye movement of eleven participants during a selection of best photos [60]. The findings of this study noted that people wasted more time on analysing highly appalling photograph. Consequently, most of them agreed to choose a highly appalling photograph as their best photo. However, the later estimates the quality measures from photos directly and automatically. Prior attempts in tourism have mainly adopted the subjective methods to evaluate photos on websites [81, 179, 46], which is slow and inconvenient for large scale analysis [188]. The

objective methods are suitable for automatic assessment of photos quality.

Various visual features were employed to represent the aesthetics of photo [35], or to examine their influence on human emotion [119], such as saturation, brightness, colourfulness, colour count saturation, hue, texture, size and ratio. Sprawls (2016) used a different set of visual features to describe photo quality such as sharpness, contrast, noise artefacts, distortion, compromises, distortion [174]. The assessment of photo quality has been receiving great attention from computer scientists, with new visual features continue to be defined [104, 102].

Photo quality assessment is an important but challenging task for researchers and tourism managers in evaluating the effectiveness of their websites or gaining insights into traveller's perception. Very limited attempts in tourism literature have been made in assessing the quality of online photos due to the limitation of existing approach in photo assessment. Computer science researchers have proposed various techniques for extracting visual features of photos. However, no attempt have been made to examine their perform in applications to online travel photos, which prevent them from widely adopted in the tourism context.

2.3.5 Photo Assessment in Hotel Applications

Some attempts were found in tourism literature to assess specifically online hotel photos to support hotel manager's decision making. Indeed a few research studies have clarified the significance of photos for online promotion of the hotel businesses on their websites [139, 192, 38, 135]. For instances, Jeong & Choi (2005) measures the influence of photo presentations on a hotel website to customers' feelings and aims of purchasing online. Their study has established a visual content examination

with 203 existing hotel Websites from hotels based in New York City. Because of no prior studies found in this area, Jeong & Choi (2005) have used three approaches such as format, content, and reality of photo appearances in order to designed eight hypothetical hotel Websites based on the content evaluation of the hotels websites as well as in the scope of conventional advertising and online advertising. The discovery of this study has illustrated that customers are most likely to have favourable attitudes toward the website of the hotel if a variety of photos are included on the website such as featured service employees or visitors in the photos. As a consequence, customers could easily imagine the overall representation of the hotel and advantages of the services they offer and at the same time actually visualise and experiencing the service [81]. A study by Lisa and Ruth (2003) have indicated that the photo included in an e-mail cause increased amount of return feedback rate from the hotel's travellers [106]. Stringam & Jr (2010) focus on exploring the impression of users about the visual content on hotel websites such as photos, colour and other information [179]. The most important factor that was identified to be the most impacting in the process on the decision of booking was the presence of photographs on a hotel website [141, 46]. A research study by Phelan et al. (2011) has examined the website impact on customers and their probability of purchasing. In order to get this study done, 28 people took place, mostly young college students that were familiar with technology. A list of 30 hotel websites were evaluated, form hotels in US popular tourist destinations. The results of this research have illustrated the importance of photographs on the hotel websites with close to 70% of respondents referring to this feature as well as how photos were impacting travellers booking decision. Other characteristics influencing booking decisions involved the colour of the website, available links, ease of use as well

as the website uniqueness [141]. In addition, Kuo et al. (2015) intended to discover the influence of misleading photographs on the hotel websites such as customers' negative word-of-mouth (WOM) intention, emotional reactions and brand trust [92]. The importance of these influences in various circumstances was explored. The finding of this study suggests that misleading website photographs would lead to reduced brand trust from the customers, therefore, affecting the upscale hotels more than the economy hotels. It is recommended that hotel businesses need to change the approach of applying only 'perfect' or highly edited photos on their websites. Considering photos that are taken in more natural setting such as photographs taken from hotels travellers would help hotel companies to set proper tourist expectations and build brand trust. Ro et al. (2013) have focused on affective image positioning of major hotels located in Las Vegas. By assessing people's perceptions of similarity based on online photos, they developed a positioning map for twelve major hotels on the Strip. Then, they interpret the configuration of hotels on the positioning map with an aid of affective scales. They believe that the emotional placement tool can contribute to the essential perception of the hotel marketers and operators, and be particularly useful in enhancing the hotel's competitive image. In order to minimise order effects, two forms of surveys were used by counter balancing the order of hotels and their similarity measures. Subjects were randomly assigned to either of the two surveys. In order to familiarise the participants with hotel images, they used the following procedures. First, the participants were asked to go to the specified website that had the links to the hotels. Then, the participants were asked to visit twelve hotel links and watch the photo slide show portraying the images of the hotel. After viewing each slide show, the participants were presented with affect scales to rate the hotel.

Next, participants were presented with 66 pairs of hotels and asked to rate them in terms of perceived similarity. In addition, they asked them to indicate the helpfulness of the photo slideshow in creating an image of the hotel. The sample was comprised of females (65%), and the mean age was 21 years. The average completion time was 85 minutes (minimum, 25 minutes; maximum, 210 minutes). Helpfulness of the slides was 5.8 on average indicating that the photo slides were effective for creating the image of the hotel [150]. An emotional oriented qualitative research study by Lo, K. P.-Y. (2008) has aimed to discover the opportunities that were designed for improving the experience of the customers that stay in the hotel particularly of female business travellers. Lo, K. P.-Y. (2008) has used two main methods in order to discover hotel customers emotions in his research project. The first one has employed photo elicitation as the main method and the second method applied in-depth interviews. Photo elicitation has based on 27 Hong Kong women who have travelled on their business trip outside of Hong Kong. They were asked to take photos of the things that got their attention most while they stay in the hotel. Furthermore, In-depth Interviews was also based on women from Hong Kong that were travelling for business purposes outside of their city. In order to understand their memorable hotel stay experiences, semi-structured questioners were conducted. The finding of this study has reported that participants have mostly enjoyable experiences while they stayed in the hotels [110].

Moreover, Sivaji et al. (2014) have investigated hotel photo gallery from traveller photographs particularly inner room and facilities provided in the Malaysian hotels. Their study was focused on understanding the importance of photo galleries and

tourist emotional responses against various types of photographs from hotels. Fourteen Malaysian tourists have taken place in this introduced study where both professional and travel photographs were examined. This study has shown that Malaysians travellers agreed that professional photographs got their attention much more toward the hotel and perceived room quality in comparison to traveller photographs. They also confirmed that photo gallery was very important for them [169]. On the other hand, another study by Tzuaan et al. (2014) has examined the visual content of hotels website using eye movements tracking technique. In their study, a group of Malaysian participants have also took place. They were asked to explain the purpose of the website homepage in a minute time. The result of this study has shown that Malaysian participants got engaged more on visual information on the hotel website associatedwith booking and price. The outcome has also demonstrated that they have neglected the significant photos from the hotel taken from outside found on the hotel homepage website [192]. Another study carried out an online survey for getting knowledge of online travellers' favourable hotel features in the process of appropriate accomodation selection [38]. The result revealed an online respondent would prefer a high-quality photograph of a hotel room when they search for accomodation. The online respondents also pointed out that the exterior hotel photographs were less important than photographs from hotels room. Countryman & Jang (2006) study examines the atmospheric features of colour, lighting, layout, style using photographs of a hotel lobby [30]. Three of the atmospheric features (colour, lighting, and style) were discovered to be the most important factors to the general opinion and impression of a hotel lobby. The colour was found as the most essential element among these three atmospheric features. Yet, these works have examined how the photos

influence hotel travellers they have not taken photo quality into consideration.

The influence of online photos to travellers' attitudes and intentions was usually examined using surveying approach [81, 179, 46]. Travellers were asked to describe their impression about visual content posted on the hotel websites. The problem with this approach is that travellers' opinions are often subjective. Different individuals may have different impression or feeling about the similar visual content. It is also hard for hotel managers to objectively determine which photos are in fact of high quality for including in their promotion materials. There is not a quantitative method reported in tourism and hospitality literature that can help tourism managers to objectively evaluate the photo quality and determine the photo visual content.

2.4 Photo Processing Techniques

After searching and reviewing for some visual data analysis in the tourism context in the previous section, we also look at potential methods and tools in computer science, related to photo processing. In this section we only focus on studies that bring more knowledge about different photo processing techniques in evaluating visual photo content and visual quality as well as various application where they were used. The details in photo processing techniques are provided as follows:

Machine Learning in Photo Content Recognition: The primary purpose of this category is to examine different machine learning techniques used in computer science for visual photo content analysis. Various prior and current machine learning methods have been listed as well as a shortcoming of such techniques are also demonstrated. For example, Vailaya et al. (1998, 2001) consider the

hierarchical classification of holiday photos and show that low-level features can successfully discriminate into many scenes types using a hierarchical structure [198, 197]. Colour feature of photographs was the primary focus in the study of Silakari et al. (2009) [166]. On the other hand, Sleit et al. (2011) have minty focused on K-means clustering to several groups of photographs using the Gabor filters, colour histogram, Fourier transformation for texture, colour, and shape feature extraction [171].Furthermore, the integration of the local SIFT (Scale Invariant Feature Transformation) feature with the global CLD (Color Layout Descriptor) feature was found in the work of Huang (2009), where the affinity propagation clustering algorithm was embraced without the necessity to initialise the number of clusters [72].

Visual features in Photo Quality: The main task of this category is to identify different visual features used in computer science for evaluating visual photo quality. For instance, Li (2002) has predicted the quality of photos by introducing a technique that has modelled the degradation of the photograph in accordance with noise and sharpness features [103]. Moreover, Li and Chen (2009) has mainly focused on examining the aesthetics visual quality of paintings by presenting an approach where they divided the whole photo into a few segments using a graph cut method and then extracted contrast and colour features in every region [100]. Another a two-stage quality indicator technique for photo visual quality evaluation has proposed by Zhang et al. (2011). In their study, they used global and local structural activity features [214].

Applications in Photo Processing: The aim of this category is on applications in computer science using image processing techniques. These studies show various

applications where visual photo content and quality assessment have been used. Such analysis is beneficial in order to get better knowledge about the methods and techniques used in analysing this visual data. For example, Chen et al. (2011) study use image-based landmark recognition from mobile phone images specifically in San Francisco area [24]. Shrivastava et al. (2011) have designed an application for finding photographs that are visually similar even though they could be reasonably different in their raw pixel level. This application has been specifically made for matching photos throughout visual domains, such as images over various seasons or lighting circumstances, illustrates, hand drawings, paintings etc. [165]. Furthermore, Ke et al. (2006) have introduced a principled approach for developing particularly high-level features for evaluation image quality. Their approach has been able to categorise low-quality snapshots from high-quality professional photographs [84].

2.4.1 Machine Learning in Photo Content Recognition

The rapid increase in User Generated Content (UGC) online has attracted growing research interests in tourism photo detection, using social media data. A massive number of photos are created everyday, that involves the need for easier and quicker way of classifying, organising and accessing them efficiently. Thorpe et al. (1996) found that people have an ability to categorise complicated photo scenes instantly [187]. Fei-Fei et al. (2002) at the same time demonstrated that minor or almost without any effort is required for such quick photo scene classification [52]. For that reason scene categorisation of photographs into semantic groups such as coastline, mountain and street with no human interaction is a complicated and severe issue in

computer science today.

A diverse number of techniques regarding photo scene categorisation have been suggested in the recent years. Unlike subjective learning approach [181], the clustering technique is able to classify a collection of unsupervised (unlabelled) photos into various clusters according to their low-level visual features. Vailaya et al. (1998, 2001) have studied the hierarchical categorisation of holiday photos and illustrated that low-level features are capable of effectively separate photos into various scene groups based on a hierarchical structure [198, 197]. Employing binary Bayesian classifiers, they made an effort to take high-level concepts from low-level photo features in accordance with the constraint that the analysed photo is part of one of the categories. Silakari et al. (2009) have aimed at a colour feature of photos [166]. The features were extracted using the colour moment and Block Truncation Coding (BTC), and then K-means clustering method was employed to categorise thousands of photos into ten clusters for instance bus, dinosaur, flower etc. Sleit et al. (2011) have utilised the colour histogram, Gabor filters, and Fourier transformation for colour, textures, and shapes features extraction, appropriately to classify photos referring to K-means clustering [171]. The outcome photo database contained four particular categories such as dinosaur, flower, bus, elephant etc. Huang (2009) has implemented the local SIFT (Scale Invariant Feature Transformation) feature with the global CLD (Color Layout Descriptor) feature and embraced the affinity propagation clustering method without the necessity to initialise the amount of clusters [72]. Moreover, for improved clustering performances, re-clustering with the bag of visual word model was employed. The dataset was made out of 750 categories which each of them include four photos.

Most of those methods of image classification above use models trained of a relatively small datasets, made of 10,000 to 100,000 of photos (e.g., NORB [97], Caltech-101/256 [51, 63], and CIFAR-10/100 [89]). However, in the past, modest visual recognition assignments could be identified much easier with datasets of these sizes, but objects in real environments revealed a significant inconsistency. Therefore much bigger training sets are required in order to be able to learn to recognise them. The disadvantages of small-sized photo datasets were broadly known [143], but it has only lately become possible to accumulate labelled datasets with millions of photos. For example, the current bigger datasets involve [153], that includes in between 100,000 and 1,000,000 of fully-segmented photos, and ImageNet [37], that contains more than fifteen million labelled big resolution photos in more than 22,000 groups.

Present methods for visual photo recognition make significant use of computer power, and they are inefficient when it comes to content recognition of big data. To improve their functionalities, we should accumulate bigger datasets, implement more robust models as well as employ improved methods in order to avoid overfitting. Convolutional neural networks (CNNs) constitute one such class of models [97, 78, 90, 98, 96, 144, 190]. Their capability can be managed by diverse intensity and comprehensiveness, therefore, they achieve powerful and mostly accurate prediction from the nature of photos (namely, stationarity of statistics and locality of pixel dependencies). Hence, in comparison to the conventional feedforward neural networks layers of equally dimensions, CNNs have much less connections and specifications, and they could be trained much quicker and easier than the others.

2.4.2 Visual features in Photo Quality

The research of visual photo quality assessment increases progressively among photo analysis and computer vision society in the past few years. Even though numerous research on photographs aesthetics evaluation have been designed, it is yet an extensively serious issue caused by various reasons. In the first place, evaluating the aesthetic aspect of a photograph is a personal opinion. Various individuals might have different inclinations to an identical photo due to diverse personal feelings as well as the background of cultures and educations, that creates absence of substantial agreement and uncertain definition of aesthetics. In the second place, the perceived quality of a photo is influenced by various features, specifically sharpness, composition, lighting and appropriate contrast, as well as particular visual methods. Earlier studies tried to employ multiple features empirically in order to identify the different appearance of aesthetics quality. Therefore, develop the commonly established principles intuitively to model the aesthetics assessment [113].

Damera-Venkata et al. (2000) introduced a technique referring to the degradation model in a frequency domain to evaluate photo quality [33]. Similarly, Li (2002) proposed a method to examine the quality of photos by modelling the photo degradation based on sharpness and noise features [103]. On the other hand, Datta et al. (2006) developed a technique to return photos that could provoke people by including extra features from an aspect of aesthetics [35]. To differentiate low aesthetics quality photos from those with high-quality, Ke et al. (2006) applied Bayes classifier with a set of high-level visual features, specifically colour distribution, hue count, a spatial distribution of edges, etc. [84]. From the opposing point of view, other researchers

favoured examining low-level features, such as log-Gabor energy based phase congruency features that were unresponsive to noises, to assess the perceptual quality [155]. Zhang et al. (2014) suggested graphlets connected graphs by adjacent regions to assess the aesthetics of photos, in order to learn the photo descriptors that describe the spatial structure of the local photo regions [215].

In general, professional photographers adopt different camera settings and approach when taking a different type of photographs. That means many aesthetics evaluation standards are taken into consideration in accordance with the content of photographs. Therefore, in order to find the drawbacks of depending on global features just, a few studies aimed their researches on local features that achieve better performance to estimate aesthetics quality. Li and Chen (2009) assess the aesthetics visual quality of paintings by applying a graph cut method. They separated the whole photograph into different segments and then extracted contrast and colour features in each region [100]. Inspired by the principles of a clear topic, focusing on the subject and blurring the background, Luo and Tang (2008) introduced a photo quality assessment technique that divided clean regions from the background and implements diverse features on them [116]. In order to improve the performance of mimicking the aesthetical perception as human, other studies have separated the photos into seven categories according to their contents, then regional and global features were extracted and combined into different groups [115, 184]. Zhang et al. (2011) suggested a two-stage quality indicator method to evaluate the photo quality by employing local and global structural activity features [214].

Furthermore, Savakis et al. (2000) proposed a subjective assessment of the importance of various visual aspects for the determination of the overall appearance

of natural photos, in the current situation photos taken from customers [156]. The outcome of this study shows that, while the primary aspects are correlated to the existence of certain concepts such as people or aesthetic quality such as composition, other particular objective evaluations of visual features deliver substantial correspondence to people's predictions. These outcomes were encouraged by the research of Winkler (2001) and Wee et al. (2007), where they introduced methods to measure sharpness and colourfulness of photos and conduct comprehensive subjective analysis illustrating the qualities of these features as useful indicators of photo attraction [206, 203]. In addition metrics such as exposure [157], contrast [210, 140], or texture features [123] have also been applied with varying levels of success in order to deliver metrics of photo attraction. These metrics have been used for photo retrieval and management applications, such as identification and removal of unwanted photos from photo collections [157].

Computational approaches for visual extraction features from digital photos have been a popular subject among research lately. Although there are many approaches proposed in computer science examining visual features for photo quality assessment, these methods have not been employed in a large dataset to test their efficiency.

2.4.3 Applications in Photo Processing

Photo processing has been a highly challenging problem for computer scientists since the invention of computers. Many different applications have been introduced using these computer techniques for evaluating the visual data. For example, a few application have been made in photo processing applying methods for photo content recognition. Jia et al. (2006) have developed and implemented a system to perform

requests from camera phones easily by providing photos of interested objects. When people are visiting an unfamiliar city with a camera phone at hand, they can simply take a photo of an object so the system would be able to give certain information about that particular object [82]. Chen et al. (2011) study uses image-based landmark recognition from mobile phone images specifically in San Francisco area [24]. Similarly, an augmented reality system for mobile phones has been designed by Takacs et al. (2008). This system matches camera phone photos versus a big database in order to create search requests about objects in visual proximity to the consumer. Pointing with the mobile phone camera delivers a natural way of identifying people's interest and looking for information that is available at a specific location [182]. Furthermore, Shrivastava et al. (2011) have designed an application for finding visibly similar photos even if their appearance could fairly be differing at the raw pixel level. It is specifically for matching photos over visual areas, such as images taken across diverse lighting circumstances or throughout the year, for example, different seasons as well as sketches, hand-drawn, paintings etc. [165]. Imran et al. (2009) introduced a method of discovering most informational features for even recognition based on images from photo collections. The aim of this research is to automatically group different event categories according to their visual content of a type of images that create the event [75].

Apart from the photo processing in visual photo content recognition, visual photo quality has also been introduced in various applications. For example, Ke et al. (2006) introduced a standardised methods for differentiating high-level features for photo quality assessment. Their developed system is able to categorised among high-quality professional photos and low-quality snapshots [84]. Also, Datta and Wang (2010)

present a publicly accessible system that gives consumers opportunity to upload their photos and have them ranked in accordance with aesthetic quality [36]. This system is the first publicly available application for automatically evaluating the aesthetic value of a photo, and this work is a substantial first move in recognising people's emotional response to the visual stimulus. However, this system limitation is that it can only assess one photograph at the time. Another interactive application which allows consumers to enhance the visual aesthetics of their digital photos applying spatial recomposition was also introduced. Different than previous work that aims at either on photo quality evaluation or interactive applications for photo editing, this work enables a consumer to make their choices about making the composition of photographs better [9].

Even though image processing techniques have been applied in different applications, not many attempts have been made in tourism industry, especially in hotel business.

2.5 Summary

Understanding customer needs and experience is a crucial element of efficient planning and decision making for successful management in the hotel industry. Researchers have acknowledged that visual data such as photos have a potential of examining customer behaviours. Therefore, many different studies have been undertaken in the last few decades, analysing photos in order in order to find useful knowledge and convert in into valuable information. This chapter has reviewed the literature about visual data mining applications in the tourism and hotel industries and analysed the possible research problems there are facing.

Some attempts have been made in visual photo content/quality assessment exploring tourist interests and experience. Only limited number of studies have been devoted to examining the online travel photos for better understanding of the destination image perceived by travellers. However, they solely rely on manual analysis approach focused only on photos in tourism in general. Unfortunately, limited attempts have been made to examine their performance in applications in online hotel photos specifically.

Computer science researchers have proposed various photo processing techniques such as machine learning methods in photo content recognition or extracting visual features in photo quality assessment. Even though photo processing methods have a potential of exploring customer behaviour, it has not been adopted in tourism applications yet. In our thesis here we use these developed photo processing techniques and apply to our work to help hotel managers discover customer's needs and experience from online hotel photos.

Chapter 3

Visual Photo Content Assessment

Even though photos provide excellent sources for exploring tourist interests, which are very useful to both potential travellers and the tourism/hotel industry, there were very limited attempts in tourism literature to assess the photo visual content. That is probably due to the current approaches to photo recognition that make significant use of computer power and that is a case especially with larger datasets such as ours here.

Addressing the above mentioned challenges, this chapter analyses the visual content from online hotel photos using automated computer approach with machine learning model trained from one of the biggest CNNs to date. A number of different experiments were carried out in the forthcoming sections to validate the introduced model for photo content assessment such as explore the photo content differences between various groups of travellers to discover their interests.

The structure of this chapter is organised as follows. Firstly, section 3.1 describes the methodology development in this study. Details about how the model was trained and why we chose this one are first represented in Section 3.1.1, which is then followed by how we implemented it and better organised the final output labels in Section 3.1.2.

Then, the next Section 3.2 reports the experiment, which begins with data collection and is then followed by the result and analyses. Finally, the implications and the summary are presented in Section 3.3 and Section 3.4 respectively.

3.1 Methodology

3.1.1 Our Model based on Convolutional neural networks (CNNs)

As we have mentioned before in Section 2.4.1, current approaches to object recognition make significant use of machine learning methods and that is a case especially with larger datasets, thus, in order to delivery efficiency in our study here we need to use more robust models and better techniques for preventing overfitting. CNNs constitute one such class of models [97, 78, 90, 98, 96, 144, 190], therefore, in our research we use a model trained of a large, deep CNNs [91].

The model was trained from one of the biggest CNNs up till now, and it was used a part of ImageNet that is a huge dataset made of more than fifteen million big resolution labelled photos which belong to approximately 22,000 classes. The photos were gathered online and self-processed by people labellers using Amazon's Mechanical Turk crowd-sourcing technique. Everything has begun, in the yearly contest named the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) that was held as a part of the Pascal Visual Object Challenge in 2010. ILSVRC employs a portion of ImageNet with approximately a thousand photos in each of their thousands of classes. Altogether, having approximately 1.2 million training photos, which 150,000 were used as testing photos and 50,000 of them were only used as validation

photos. The trained model used in our research has accomplished undoubtedly the best performances ever announced on these datasets, and this network contains many modern and rare features that enhance the efficiency and at the same time decreases the training time [91].

ImageNet consists photos of inconstant resolution, while in this system a consistent input resolution photos is a necessity. Thus, while the model was trained photos were down-scaled to a permanent resolution of 256 by 256. Given a rectangular picture, the system first rescaled the photo such that the shorter side was of length 256 and then cropped out the central 256 by 256 patch from the final photograph. The system did not use any processing methods beforehand, apart from the subtracting the mean activity over the training set from each pixel. Consequently, the network was trained on the (cantered) raw RGB values of the pixels.

The traditional method to model a neuron's output f as a function of its input x is with $f(x) = tanh(x)$ or $f(x) = (1 + e - x) - 1$. Regarding training time with gradient descent, these saturating nonlinearities having limited speed in comparison to the non-saturating nonlinearity $f(x) = max(0, x)$. Similar to Nair and Hinton [129], this system refers to neurones with this nonlinearity as Rectified Linear Units (ReLUs). Deep CNNs with ReLUs have training speed which is several times quicker than their equals using tanh units. This shows that the system would not have been able to experiment with such large neural networks for this work if it had used traditional saturating neurone models. This system was not the first to consider alternatives to traditional neurone models in CNNs. For instance, Jarrett et al. (2009) have proved that the nonlinearity $f(x) = |tanh(x)|$ works well especially with their kind of contrast normalisation succeeded by local average pooling on the Caltech-101 dataset

[78]. They claim quicker learning has a significant impact on the functionalities of their huge models that have been trained on big datasets.

ReLUs have been known for their beneficial characteristics of no need of input normalisation to stop them from saturating. For example, if at least some training examples produce a positive input to a ReLU, learning will happen in that neuron. Nevertheless, this system has found that the subsequent local normalisation scheme aided generalisation. Denoting by $a^i_{x,y}$ the activity of a neuron computed by applying kernel i at position (x, y) and then using the ReLU nonlinearity, the response-normalized activity $b^i_{x,y}$ is given by the equation 3.1.1.

$$b^i_{x,y} = a^i_{x,y} / \left(\kappa + \alpha \sum_{j=max(0,i-n/2)}^{min(N-1,i+n/2)} (a^i_{x,y}) \right)^{\beta} \tag{3.1.1}$$

where the sum performs over n "adjacent" kernel maps at the same spatial position, and N is the total number of kernels in the layer. Beforehand the actual training begins, the ordering of the kernel maps has been arbitrary and determined. This kind of feedback normalisation applies a model of sidewaysrestriction stimulated from the type found in real neurons, producingcontest for significant activities between neuron outputs computed using different kernels. The constants k, n, α, and β are hyper-parameters whose values are determined using a validation set.

The system has included eight layers with weights, where the first five of them have been traditional, and the rest three of them has been fully connected. The result of the very last layer which is fully connected has been fed to a thousand way softmax that has generated a delivery through the thousand class labels.

Table 3.1: Grouped Labels

Hotel Bedroom	studio couch, day bed, four-poster, quilt, comforter, comfort, puff	**Dining Place**	restaurant, eating house, eating place, eatery, dining table, plate
Bathroom	washbasin, handbasin, washbowl, lavabo, wash-hand basin, toilet seat, bathtub, bathing tub, bath, tub, shower curtain, toilet tissue, toilet paper, bathroom tissue	**City Buildings**	palace, cinema, movie theatre, movie theatre, movie house, picture palace
Kitchen Place	microwave, microwave oven, refrigerator, icebox	**Room Windows**	sliding door, window shade

3.1.2 Model Implementation

We applied this already trained model to all of our photos in our research. Each photo was classified into 1,000 different categories (labels) where the first label is considered as most probable by the model and the last one (the 1,000th) as least apparent category. However, we found a lot of the labels had similar or same meaning, therefore, we decide further to group them together into one category. For example: restaurant, eating house, eating place, dining table, plate were given a label name *Dining Place*, microwave, microwave oven, refrigerator, icebox as *Kitchen Place* or washbasin, washbowl, lavabo, wash-hand basin, toilet seat, bathtub, bathing tub, bath, shower curtain, toilet tissue, bathroom tissue as *Bathroom* and etc. In this case we ended up with less and better organised labels. All the labels grouped together are shown in Table 3.1.

Furthermore, we listed the most photographed labels from both *Travellers* and *Management* photos and then from each of the labels we manually picked 50 random photos. Each of those photos was compared with the given label name and calculated the precision, e.g. how many percentages of the photos are actually classified correctly.

For instance, let say that we what to estimate the precision in *Dinning Place* label. We randomly pick 50 photos with that label and then going through them one by one and see if the actual predicted label matching with the actual content of that photo. If the photograph is classified as *Dinning Place* and in the photos is something else, then we consider that one like *False* and all the way around we regard as *True*. The precision is calculated based on how many photographs we have chosen as *True* out of all those 50 photos. We eliminate all those labels where the precision was less than 0.6 or (60%). The final chosen labels and their precision rates are shown in Table 3.3. Table 3.2 shows the final photographed labels used in our study here along with the number of photos, percentages and ranking.

3.2 Experiment

3.2.1 Data Privacy

Since data privacy is such a prevalent issue in these digital ages, it's essential the personal information of customers shared online be kept private. People are researching, purchasing and using online products and services, via any number of connected devices. They are also opting in to share their preferences as part of interactions on social media and search sites. Consumers have also become increasingly concerned about the information they constantly sharing online. Privacy is about respecting individuals, therefore, protect their information private is very important to all of us. Before we continue with any further data analysis in this thesis, we would like to state that the data used in our experiment has not been using any private information of the individuals. All information is publicly available on the web and anyone can

Table 3.2: Final Most Photographed Labels

	Content Labels	No. Photos	Percentage	Ranking
Managemet	Dining Place	401	13.67	1
	Hotel Bedroom	394	13.43	2
	Living Room	364	12.41	3
	Bathroom	178	6.07	4
	Room Windows	141	4.81	5
	Kitchen Place	114	3.89	6
	City Buildings	90	3.07	7
	Terrace	71	2.42	8
	Cityscape	45	1.53	9
Travelers	Bathroom	935	14.35	1
	Hotel Bedroom	754	11.58	2
	Living Room	679	10.42	3
	Room Windows	310	4.76	4
	Kitchen Place	272	4.18	5
	Dining Place	271	4.16	6
	Cityscape	248	3.81	7
	City Buildings	173	2.66	8
	Wardrobe Closet	127	1.95	9
	Skyscrapers	117	1.80	10

access them at any time. The pieces of information used in our analysis are hotel reviews from tourists shared publicly online on one of the most popular travels related web platform TripAdvisor (www.tripadvisor.com), in order to encourage and support other travellers with the choice of their accommodation when travelling.

Table 3.3: Labels Precision

Management		**Travelers**	
Lable	**Precision**	**Lable**	**Precision**
Dining Place	0.88	Bathroom	0.92
Hotel Bedroom	0.82	Hotel Bedroom	0.88
Living Room	0.84	Living Room	0.90
Bathroom	0.92	Room Windows	0.88
Room Windows	0.82	Kitchen Place	0.84
Kitchen Place	0.90	Dining Place	0.84
City Buildings	0.88	Cityscape	0.94
Terrace	0.82	City Buildings	0.94
Cityscape	0.80	Wardrobe Closet	0.64
		Skyscrapers	0.92

3.2.2 Data Collection

The data used in our study was taken from TripAdvisor (www.tripadvisor.com), one popular travel review websites. This website has been widely used as a data resource for research on hotel preferences and selection criteria of tourists' [101, 104]. We developed a web data extraction software to download photos, which were posted by travellers when they made review comments. Other demographic information such as traveler's location of origin and travel mode are also extracted. Photos posted by hotel managers are included in the data extraction process for later comparative analysis.

We use the term *traveler photos* and *management photos* to distinguish the photos posted by travellers and hotel managers respectively.

We focus the data extraction on hotels in Melbourne, as one popular Australian

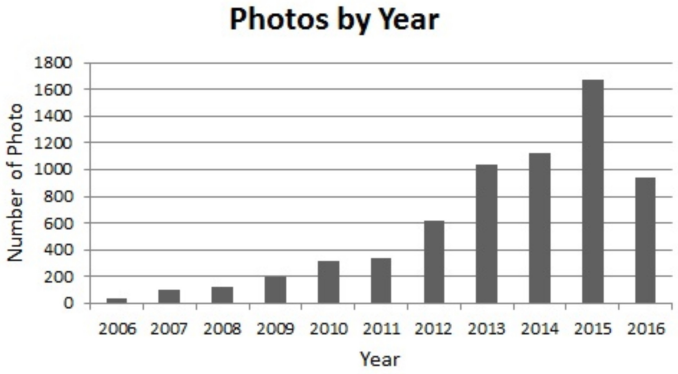


Figure 3.1: Numbers of photos posted by Travellers

tourism destination. It is possible that some hotels are newly listed without any users reviews or photos, and some users did not provide their location of origins. We exclude them from our data collection. In addition, our study focus on inbound tourists to Australia, therefore, we do not account for photos posted by Australian residents. Totally, 9,448 photos for 120 hotels were analysed, among which, 6,514 photos were posted by travellers, and 2,934 photos were posted by hotel managers.

Figure 3.1 shows the number of photos posted by travellers by year. Most photos were uploaded in recent years with increasing numbers, which indicates the increasing popularity of travel websites such as TripAdvisor for travelers. Please be noted that the number of photos in 2016 is less than some preceding years as the data collection was carried out in early 2016, thus the data for the full year was not yet available. A series different of experiments are carried out in the subsequence sections to validate the introduced visual features for quality assessment.

3.2.3 Traveller vs. Management Photos

Photos posted online by the Travellers during their stay in the hotels or right after their trip provide an excellent source for tracking customers behaviour and experience. Hotel Managers often mislead Travellers interests when they advertised their hotel businesses online, or they focus on entirely different subjects. Addressing customers needs based on *Traveller* photos could help Managers better understand Travellers and find out what is the interest differences between the photos taken from the *Management* and *Travellers* and in that way to build better strategic planning.

Exactly, this section presents a comparative visual content analysis between photos taken from the *Travellers* versus photos taken by the *Management*. Z-*test* statistical test with significance level of $p \leq 0.05$ was applied to verify the significance, therefore, we have not shown any results where the level of significance was $p > 0.05$. As has been seen in Table 3.4, Hotel Management are interested more photographing *Dining Place*, *Hotel Bedroom*, *Living Room* and *Terrace* where Hotel Travellers focus more in *Bathroom*, *Cityscape*, *Skyscrapers*, *Wardrobe Closet*. From here we can see that hotel Managers are more interested in promoting their indoor hotel facilities rather than Travellers where besides Hotel accomodation are also involved in outdoor activities as such as: *Cityscape* and *Skyscrapers*. There is a noticeable variance between the photo subjects *Dinning Place* and *Bathroom*. Managers seem to focus mostly on photographing *Dinning Place* with 9.51% differences between the *Managers* and *Travellers*. *Bathroom* appears the opposite with 8.28% differences and also becomes mainly photograph subject from *Travellers*.

Table 3.4: Travelers vs. Management

	Management	**Travelers**	**Differneces**	**Z-Score**	**P-value**
Dining Place	13.67%	4.16%	9.51%	16.6356	0.00
Hotel Bedroom	13.43%	11.58%	1.85%	2.5518	0.01
Living Room	12.41%	10.42%	1.99%	2.8454	0.00
Bathroom	6.07%	14.35%	8.28%	-11.5615	0.00
Terrace	2.42%	0.78%	1.64%	6.5214	0.00
Cityscape	1.53%	3.81%	2.28%	-5.8985	0.00
Skyscrapers	0.65%	1.80%	1.15%	-4.3369	0.00
Wardrobe Closet	0.24%	1.95%	1.71%	-6.5083	0.00

3.2.4 Business Traveller vs. Leisure Traveller Photos

Furthermore, we made a comparison between different traveler's types. Knowing a specific travel group preferences when they travel and stay in the hotels could be beneficial to the Hotel Managers as well. To determine the differences between these categories we have divided them into two groups *Business Travellers* including people who travel on their business trips and *Leisure Travellers* people being on their holidays such as: (family, solo, couple, friends). A Z-*test* with significance level of $p \leq 0.05$ was also applied. As shown in Table 3.5, *Business Travellers* are more interested of taking photos of *Room Windows* and *Cityscape*. On the other hand *Leisure Travellers* have shown more interest in *Kitchen Place*, *City Buildings*, *Wardrobe Closet*. From here we can see that both travel groups tend to be involved similarly in indoor and outdoor activities altogether. In Table 3.5 are shown only the results where the level of significance is 0.05 or less.

Table 3.5: Business Travelers vs. Leisure Travelers

	Business	**Leisure**	**Differneces**	**Z-Score**	**P-value**
Room Windows	5.93%	4.40%	1.53%	2.4614	0.01
Kitchen Place	3.32%	4.44%	1.12%	-1.9113	0.03
Cityscape	4.87%	2.47%	2.4%	2.5263	0.01
City Buildings	2.02%	2.85%	0.83%	-1.7734	0.04
Wardrobe Closet	1.37%	2.13%	0.76%	-1.885	0.03

3.2.5 Photos in Positive vs. Negative Reviews

A clear knowledge of what make travellers happy or what is annoying about their stay in the hotel could be useful for tracing customers interests and at the same time helpful for hotel owners for better business planning. For this analysis we divid our photos into *Positive* and *Negative* photos. More specifically, when posting the comments and photos onto TripAdvisor online platform, some users also provide their overall rating (between 1 and 5) toward the hotel. We group the photos in reviews comments with 3 star rating or above into *Positive* group, photos in review comments with 2 star rating or less are group into *Negative* group. Table 3.6 presents all results where the Z-*test* level of significance is $p \leq 0.05$. We can see that photos taken from *Bathroom* are mention more in a negative connotation rather then photos taken of *Living Room* where it seems to be positive. There are no negative photos taken from *Wardrobe Closet* label, therefore, we consider it as a positive.

Table 3.6: Positive VS. Negative

	Negative	**Positive**	**Differneces**	**Z-Score**	**P-value**
Bathroom	18.30%	13.48%	4.82%	2.0718	0.02
Living Room	7.23%	11.12%	3.89%	-1.8522	0.03
Wardrobe Closet	0.00%	2.30%	2.3%	-2.3528	0.01

3.2.6 Hotel Star Rating - Three and Below vs. Four and Above

Marketing strategy plays a critical role in the hotel business in order to attract new customers. Big hotel names spend a significant amount of money just to make sure they advertise their businesses correctly. Showing the right photos on their hotel websites it is beneficial, therefore understand what type of photos better hotel brands used in their marketing online could be helpful for the smaller hotel business.

Last but not least, we analyse the photos taken by the Management from different hotels star rating. When we use TripAdvisor platform to search for accommodation, hotels are also provided with star rating (between 1 and 5). For that purpose, in our analysis we divided our dataset onto *Three stars and Below* and *Four stars and Above*. We applied again Z-*test* and only four labels have shown level of significance $p \leq 0.05$. As shown in Table 3.7, *Bathroom*, *Hotel Bedroom* and *City Buildings* are mostly photograph labels in the hotels with *Three stars and Below*, where *Dining Place* is generally mainly photography label in hotels with *Four stars and Above*.

Table 3.7: Hotel Star Rating - 3 and Below vs. 4 and Above

	3 and Below	**4 and Above**	**Differneces**	**Z-Score**	**P-value**
Bathroom	8.89%	5.60%	3.29%	2.6077	0.01
Hotel Bedroom	18.27%	12.63%	5.64%	3.1256	0.00
Dining Place	8.65%	14.50%	5.85%	-3.2134	0.00
City Buildings	6.25%	2.54%	3.71%	4.0634	0.00

3.3 Implications

The results in Table 3.4 demonstrate the actual differences between visual content from the online photos of what hotel managers advertise and what travellers actually recognised. Usually, the hotel managers would hire a professional photographer to take the best images of their hotel facilities including nice and clean accommodation with a great view outside from their hotel rooms in order to deliver a pleasant feeling that the rooms offered in the hotel are comfortable, tidy, neat and beautiful. Nonetheless, a photograph taken by hotel customers might reveal otherwise, such as the real world of the hotel room, and it can also evoke negative feeling to the customers if the hotel facilities especially the hotel room does not match to the photos shown online. For that reason, hotel managers should be careful about photos chosen for online marketing in order to avoid disappointment to their customers. Understanding the perception of different travel groups are also important for managers to gain insights into traveller's perceptions. For instance, while *Leisure Travellers* such as families, friends, solo or couples may be interested in taking photos to share with their friends or to keep a good memory of their trip, *Business Travellers* may take pictures just

to record their travel, thus their photo content would differ from the others. A comprehensive knowledge of tourist needs could aid hotel owners achieve a lead in the market in regard to business advertising, critical planing and product improvement [205]. Table 3.5 shows the photo content differences between those two groups *Business Travellers* vs. *Leisure Travellers*. Understanding the photographs based upon customer feelings about what they have experienced is a fundamental element in the tourism (Table 3.6). For example, photos taken in a positive context such as *Living Room* would tell hotel managers that travellers really enjoy their time there, on the other hand, photos taken in negative connotation such as *Bathroom* would advise that it might be something wrong there. Different hotels focus on different photo marketing strategy. However, the most expensive and better rated hotels put a lot of effort figuring out which photos would work better for their business promotion. That is not a case with the cheaper hotels, therefore, understanding the photo content from their competitors would help hotel managers achieve better strategic planning in order to promote their businesses better. Table 3.7 shows a comparison between the hotels with different star ratings. We compared the hotels with *Three stars and bellow* with *Four stars and above*.

Mainly, hotel managers are more interested in promoting their indoor hotel facilities and their photographs are based on *Dining Place*, *Hotel Bedroom*, *Living Room* and *Terrace* where travellers besides hotel accomodation are also involved in outdoor activities as such as: *Cityscape* and *Skyscrapers*. Furthermore, both Business and Leisure travellers tend to be involved similarly in indoor and outdoor activities altogether. Photos taken from *Bathroom* are mention more in a negative connotation rather then photos taken of *Living Room* where it seems to be positive. Last but

not least *Bathroom*, *Hotel Bedroom* and *City Buildings* are mostly photograph labels in the hotels with three stars and below, where *Dining Place* is generally mainly photography label in hotels with four stars and above.

3.4 Summary

Considering that the travellers take photographs to document something that draws their attention, the traveller-supplied photos collection provides essential knowledge to understand the tourist's engagement and feelings to people and events at different places. This chapter introduces a computational approach for automatic visual content recognition from online hotel photos. The dataset used in our analysis including thousands of photographs with other demographic information such as traveller's location of origin and travel mode. Before, for photo content analysis were used survey techniques. Unfortunately, those conventional approaches were time-consuming and inefficient when it comes to a large number like ours in this chapter. Thus, to delivery efficiency in our experiment in this chapter, we adopted a machine learning model trained from one of the biggest Convolutional neural networks (CNNs) to date to evaluate visual photo content from this dataset. The efficiency of this approach is demonstrated in an application on Melbourne hotels and discovered the visual content differences between traveller photos and management photos. This study supports hotel managers for a better understanding of their customer's needs and experience as well as help them make better business planning and decision making.

In the next chapter, we extend further our analyse to the visual photo quality assessment between different groups of travellers from the hotels.

Chapter 4

Visual Photo Quality Assessment

The human's brain has the ability to easily identify high-quality from low-quality photos in the blink of an eye. They can also efficiently make a difference between photos taken in low-light conditions where the noise level is more permanent or bright and sharp photographs with nice contrast and saturated colour hues. This subjective method is slow and time-consuming especially when there is a large number of photos available. The research about visual photo quality assessment gains increasing demand in the photo processing and computer vision society lately. Even though numerous studies on photo aesthetics assessment have been suggested, it is yet a substantially severe issue due to various reasons. Such methods have not been employed in a large dataset such as ours to test their efficiency.

Considering the above mentioned challenges, this chapter presents our approach to visual photo quality assessment based on visual quality features from online hotel photos using automated computer techniques. In our research here we selected five visual features, which are helpful in reflecting the visual photo quality such as: *Brightness*, *Colourfulness*, *Contrast*, *Sharpness* and *Noisiness*. A photo that is taken at daytime it is not always better quality than a photo taken during night time. For

that reason, the evaluation of visual quality is conducted for *day* and *night* photos separately. A series of different experiments are carried out in the forthcoming sections to validate the introduced visual features for quality assessment such as explore the visual photo quality among various groups of travellers to discover the differences between them.

Having set the context for this chapter, the structure is organised as follows. Firstly, Section 4.1 describes the methodology development and details about the several visual features used in our experiment. Then, the next Section 4.2 reports the experiment, which begins with data collection and is then followed by the result and analyses. Finally, the implications and the summary are presented in Section 4.3 and Section 4.4 respectively.

4.1 Methodology

Visual Feature Description

A digital colour photo is usually represented by a two-dimensional array of integer triplets; each includes colour information of three colour channels. There are many colour spaces used to represent colour photos, such as RGB (red, green, blue), HSV (hue, saturation, value) and HSL (hue, saturation, lightness). The colour values can be converted between the colour spaces [54], to compute different visual features. We represent our photos in RGB colour space as it is a standard default colour space for the Internet [178], and various photo progressing applications [35, 119].

Visual features that describe photo characteristics such as brightness, colour and textual were found to have an influence on viewer's emotion [76, 199]. It should be

noted that some visual features proposed in previous studies are redundant as they describe similar characteristics of photos. For instance, both colourfulness and colour count describe the colour diversity in photos [119]. Either is sufficient to describe the colour of the photo, because highly colourful photos would have higher values for colourfulness or colour count feature than less colourful photos. On the other hand the two mostly find forms of degradation of a photo are loss of sharpness or blur, and noisiness [213]. For instance, high contrasted, colourful, bright and sharp photographs are accepted as more attractive, while low quality, gloomy and unclear photos with lower contrasts are often refused [156]. This is a real example even when the photos are over-processed to the extent that they appeared almost unnatural [212]. Especially colourfulness and sharpness have been determined as appropriate features in this regard [207].

We select five representative features, including *brightness*, *colourfulness*, *contrast*, *sharpness* and *noisiness*. Their details are given below.

Brightness

Brightness is a measure of the amplitude of colour intensity in digital photo, which has been shown to be effective in assessing the attractiveness of photos [138]. Let X and Y be the height and the width of a photo. The brightness visual feature is computed as follows:

$$brightness = \frac{\sum_{x,y}(0.299 * R_{x,y} + 0.587 * G_{x,y} + 0.114 * B_{x,y})}{X * Y} \tag{4.1.1}$$

where R, G and B take a value between 0 and 255 to represent the colour intensity of each single pixel at location x, y for red, green and blue respectively. The weights (0.299, 0.587, and 0.114) are defined by the International Telecommunication Union for the brightness computation [77]. The overall brightness of the photo is the average of brightness value over all pixels. Brightness feature takes a value in [0, 255]. A higher value indicates a brighter photo and vice versa.

Colorfulness

Colourfulness estimates the differences of the spectrum included in the photo, which has been demonstrated to deliver hight relationship with people's understanding of attractiveness [156]. Appealing photo tends to have higher colourfulness values [138]. Colours and colour combinations have been studied by those interested in retail atmospherics and cognitive psychology. In a former landmark research by Guilford and Smith (1959), it was found that bright and well saturated colours are more likely to create pleasant emotions [67]. While individuals might favour particular colours, it was shown that appropriateness of the colour differs with the function of the room [170]. Furthermore, it was also shown that the combination of colours are able to help people find their way in a building [47]. In retail atmospheric research, it has been verified that colour can attract customers [6] as well as the ability to stimulate pleasant emotions between customers [7].

We adopt a colourfulness metric proposed by [70] as it was proved to have a strong correlation with a human score in a psychophysical experiment, and its computation is efficient. Assume that the photo is represented in RGB colour space. The first step is to compute the complementary colour images:

$$rg = R - G; \qquad yb = \frac{1}{2}(R + G) - B \tag{4.1.2}$$

Next, the mean and standard deviation values of the pixels in the complementary colour images are computed and denoted as σ_{rg}, μ_{rg}, σ_{yb} and μ_{yb}. The colourfulness of a photo is computed as:

$$\begin{gathered} colorfulness = \sigma_{rgyb} + 0.3 * \mu_{rgyb}; \\ \sigma_{rgyb} = \sqrt{\sigma_{rg}^2 + \sigma_{yb}^2}; \qquad \sigma_{rgyb} = \sqrt{\mu_{rg}^2 + \mu_{yb}^2}; \end{gathered} \tag{4.1.3}$$

The values as computed by Equation 4.1.3 are usually in the range from 0 to 109, with 0 being not colourful and 109 being extremely colourful.

Contrast

Contrast is the difference in colour and brightness of an object that makes it distinguishable from other objects within the same view. Although multiple definitions for computing the contrast value have been proposed, we utilize the *Root Mean Square* (RMS) contrast, which has been proven effective in ranking and classifying attractiveness of photos [138]. Let i_{xy} denote the brightness of a pixel at location x, y in a photo, and $\bar{i}$ is the average brightness of all pixels. The brightness of the photo was normalized such that $i_{x,y} \in [0, 1]$. The contrast is defined as the standard deviation of pixel brightness in a photo:

$$contrast = \sqrt{\frac{1}{XY}} \sum_{x=1}^{X} \sum_{y=1}^{Y} \tag{4.1.4}$$

Contrast takes a value between 0 and 1, where a high value indicates a photo with high contrast.

Sharpness

Sharpness is relating to the clarity of detail and edge definition of a photo [22]. System sharpness can be affected by the quality of camera lens and sensor. Another inflecting factor is camera shake while capturing a photo, focus accuracy, and atmospheric disturbances. In the context of our study, the photos are mainly taken in or around a hotel with a reasonably stable environment. The sharpness of hotel photos is probably determined mainly by the camera quality. We use a relatively new Sharpness Index proposed by [10], due to its computation efficiency.

$$sharpness = -\log_{10} \Phi(\frac{\mu - TV}{\sigma}) \tag{4.1.5}$$

In the Equation 4.1.5, TV is the total variation that associates to a photo, which is defined in [10]. μ and σ are the expectation and standardization of TV respectively. Function $\Phi(x) = (2\pi)^{-1/2} \int_x^{+inf} e^{-t^2/2} dt$ is the tail x of the Gaussian distribution. There is no fixed range for the sharpness value. A higher value indicates better sharpness.

Noisiness

Noise is a random pixel level variation in the digital images, one of the key image quality factors that could cause image quality degradation. Noise can appear as randomly distributed black dots on a bright background or with dots on a dark background. We adopt a noise level estimation algorithm, recently proposed by [109], to represent the noisiness in a photo. This feature was proven to produce better results than other existing methods. The computational algorithm includes an iterative process.

1. Firstly, patches are generated from an input photo using overlapping sliding window.

2. Then an initial noise level σ_n^0 is estimated from a covariance matrix, which is generated by applying principle component analysis technique on all patches of the input photo.

3. A threshold τ_k is computed to select weak textured patch set W_k.

4. The noise level $\hat{\sigma}_n^{k+1}$ is estimated again based on W_k.

5. The processes (3) and (4) are iterated until the noise level $\hat{\sigma}$ is unchanged which result the final noise level value.

Details on the computation of the noise level from photo patches and weak texture patch set can be found in [109]. No fixed range of the noise was mentioned. Intuitively, a lower noisiness value indicates lower noise level and better photo quality.

The aforementioned visual features are suitable for quantitative assessment of photo visual quality, because, the features are represented in numeric form, which

objectively reflects the characteristics of the photos. In order to compare the overall quality of different photo collections, researchers can compute and compare average values of the photo features in each collection. Statistical tests, such as t-test and ANOVA test, can be used to verify the significance. We carry out experiments to verify the suitability of the visual features in assessing online travel photos in the next section.

4.2 Experiment

4.2.1 Data Collection

In this Chapter for the Visual Photo Quality Assessment, we use the same dataset that we already proposed earlier in Chapter 3. The data was collected from TripAdvisor (www.tripadvisor.com.au) using our custom web data extraction software to download the photos. The collected data contains 20,341 photos in total, from 120 hotels over a period of 11 years (2006 to mid-2016) including tourists from 82 different countries. Australian residents take almost 54 percent in the data, therefore, we do not account for photos posted by them. Totally, 9,448 photos were analysed in our study, among which, 6,514 photos were posted by travellers, and 2,934 photos were posted by hotel managers. As we have mentioned before in Section 3.2.2, most photos were uploaded in recent years with increasing numbers, which indicates the increasing popularity of travel websites such as TripAdvisor for travellers. Please be noted that the number of photos in 2016 is less than some preceding years as the data collection was carried out in early 2016, thus the data for the full year was not yet available. Figure 3.1 shows the number of photos posted by travellers by year. A series of different experiments

are carried out in the subsequence sections to explore the travellers' interests based on visual photo quality assessment.

4.2.2 Example Photos and Visual Features

Firstly we examine the visual features through an analysis of some sample hotel photos. Figure 4.1 shows three photos with different visual quality as perceived by the authors. Five visual features were then computed for each photo and listed at the top of the figures. We can see that the brightness, colourfulness, contrast and sharpness of the photo in Figure 4.1a are 152.37, 41.90 and 0.64 respectively, which are much higher than the same features of the photos in Figures 4.1b and 4.1c. The visual features reflect the fact that the first photo appears to be brighter, more colourful, and more pleasant to human eyes than the others. If we zoom in closer to the photos, we can see that the first photo is smooth, whereas others photos are a bit noisy with a watermark. Such differences were captured by the noisiness feature. The noisiness values for the photo in Figure 4.1a is 0.04, which is smaller than those photos in Figures 4.1b and 4.1c. Figure 4.1c appears to have lower brightness than Figure 4.1b, probably because it was taken outside of the hotel at night time. However, its colourfulness is higher than Figure 4.1b because various colours tone exists in the background due to street lights.

It should be noted that human eyes can quickly distinguish photos with significant quality differences such as between Figures 4.1a and other figures, but slow in comparing photos with relatively similar quality such as the photos in Figures 4.1b and 4.1c. It is time-consuming to examine each photo manually, especially when there is a large number of photos available. The use of visual features as quality indexes can

(a) (b)

(c)

Figure 4.1: Sample Photos and Visual Features

help assessing the photo in a quick and efficient manner.

We further examine the visual features at a larger scale using the collected hotel photo data set. It is worth pointing out that the photos can be taken at both day time and night time, such as in Figures 4.1a and 4.1c. A photo taken at night time is not necessarily being of low quality despite lower brightness. For fair comparisons, we classify the photo collection into two classes, *Day* and *Night*, to compare separately in the subsequent experiments. Due to a large number of photos available, we adopted Support Vector Machine (SVM) [183], a powerful state of the art machine learning algorithm, to help with an automatic classification for a large number of photos in our data collection. More specifically, a small number of photos were firstly selected and manually grouped into *day* and *night* classes (100 photos for each class). A vector of colour histogram is computed for each photo to represent the colour distribution [164]. We divided every colour channel into four intervals to reduce the dimension of the colour vector, which results in 64 bins for the RGB colour space. The colour of photo pixels is vector quantised into the corresponding bin and normalised between 0 and 1 so that the values do not depend on the size of the photos. SVM model was trained and tested on the selected day and night photos, using 10-fold cross validation approach [183], which achieved 94% accuracy in agreement with the human selection. The trained SVM model is then applied to the rest of the photos in our data collection to separate them into day and night photos for the subsequent analysis.

4.2.3 Management vs. Traveler Photos

High-quality photos are commonly known to give travellers positive feeling [128]. It is assumed that DMOs are interested in using quality photos in their promotional

materials such as brochures, television commercials and picture postcards to promote tourism destinations and tourism product [57]. An example of management photo was shown in Figure 4.1a. Photos in Figures 4.1b and 4.1c were in fact posted by travellers. This section presents a comparative analysis to determine if photos posted by hotel *management* are of higher quality than those photos posted by *travellers*. The trained SVM model was used to classify the photo collections into day and night photos. We found that around 85% of the photos posted by hotel managers were classified of day time, and 15% were classified as night time. The proportions of the photos posted by travellers are 72% and 28% of the day and night photos respectively.

The visual features for the photos collections are computed, whose average values are shown in Table 4.1. *T-test* with a significance level of $p \leq 0.05$ was applied. The results indicate that the photos posted by hotel managers tend to have higher quality than those posted by travellers for both day and night photos. More specifically, significantly higher mean values were found for the brightness and colourfulness. Contrast and sharpness of the management photos also have relatively higher value than travellers' photos. The Noise level in management photos was found to be lower than in travellers' photos. *P*-values are less than 0.05 in all cases, which verifies the statistical significance of the differences.

4.2.4 Recent Years vs. Former

We consider the fact that photo capturing devices have become more and more advanced due to technological development. It is a natural assumption that the photos taken recently would have better quality than before. This section verifies the capability of the visual features in capturing the differences in term of photo quality between

Table 4.1: Visual features for Management vs. Traveler Photos

Group	**Features**	**Management**	**Travelers**	***F*-statistic**	***p*-value**
Day	Brightness	136.41	119.23	30.03	0.00
	Colourfulness	35.05	29.57	3.25	0.00
	Contrast	0.59	0.52	34.50	0.00
	Sharpness	6.40	4.07	14.32	0.00
	Noise	0.44	0.77	-8.84	0.00
Night	Brightness	80.28	76.44	3.80	0.00
	Colourfulness	42.84	31.66	12.78	0.00
	Contrast	0.40	0.38	3.81	0.00
	Sharpness	6.13	5.09	2.77	0.00
	Noise	0.49	0.69	-2.09	0.02

recent years and *before* photos. The photos posted by travellers were grouped into recent years (from 2013 to 2016) vs. before (2012 and before) groups. SVM model was also applied to classify the photos into day and night classes. There are 4,774 photos in the recent years' group, with 70% day photos and 30% night photos. There are 1,739 in the group before, with 77% day photos and 23% night photos.

The mean values of visual features are computed for each photo groups, as shown in Table 4.2. *T-test* with a significance level of $p \leq 0.05$ was applied. No statistical significant was found for the differences between *recent* and *before* photos in terms of brightness and contrast for both day and night photos. However, recent photos appear to have significantly better sharpness and lower noise level than before photos. This finding is consistent with the fact that the quality of photo capturing devices has been improved with high resolution and better lenses, which allow for capturing sharper and clearer photos. The brightness and contrast are more relating to the scene being captured rather than the camera quality. Therefore, there was not significant

difference between *recent* and *before* photos for brightness and contrast. There was no significant difference between the colorfulness values of *recent* and *before* photos for day class. But for the night class, *before* photos appear to have higher colorfulness than *recent* photos. This is probably due to the scene captured in the photos rather than the camera quality, and there are only a small number of photos in this group.

Table 4.2: Visual features for Recent vs. Before photos

Group	**Features**	**Recent**	**Before**	***F*-statistic**	***p*-value**
Day	Brightness	119.35	118.98	0.60	0.55
	Colourfulness	29.47	29.82	-0.69	0.49
	Contrast	0.52	0.51	1.30	0.19
	Sharpness	4.76	2.35	17.26	0.00
	Noise	0.52	0.87	-6.53	0.00
Night	Brightness	76.36	76.72	-0.32	0.75
	Colourfulness	30.89	34.52	-3.42	0.01
	Contrast	0.38	0.39	-0.41	0.68
	Sharpness	5.60	3.22	5.76	0.00
	Noise	0.48	0.75	-2.74	0.02

4.2.4.1 Travelers Rating

Online travel photos have become a very important and powerful medium, especially in electronic marketing, because visual content can create a public image of a place and reflects tourists' perceptions of that location [189, 136]. This section examines the photos posted by travelers to determine if their visual features are aligned with travelers' perceptions. More specifically, when posting the comments and photos onto TripAdvisor platform, some users also provide their overall rating (between 1 and 5) toward the hotel. We group the photos in reviews comments with 3-star rating or

above into positive group, photos in review comments with 2 stars rating or less are group into negative group. Those photos were classified into Day and Night photos using SVM model, and we only consider photos posted in reviews with a rating in this analysis. There are totally 4,412 photos in positive group, with 70% day photos and 30% night photos. Negative group has 439 photos, with 67% day photos and 33% night photos. It appears that travelers are less likely to take or post photos if they do not have a positive feeling toward the hotel.

Table 4.3 present the mean values of the visual features in each photo groups for day and night classes. We can see that the day photos in positive review group are generally having better quality than photos in negative review group in term of brightness, colorfulness, contrast and noise level. *T-test* with a significance level of $p \leq 0.05$ verified the statistical significant of the differences. No statistical significant was found for the comparison of night photos.

Table 4.3: Visual features for photos in Positive vs. Negative Reviews

Group	**Features**	**Positive**	**Negative**	***F*-statistic**	***p*-value**
Day	Brightness	119.32	115.35	2.56	0.00
	Colourfulness	29.82	26.38	2.72	0.00
	Contrast	0.52	0.50	3.40	0.00
	Sharpness	4.19	3.64	1.41	0.08
	Noise	0.74	0.99	-1.90	0.03
Night	Brightness	76.42	79.44	-1.31	0.09
	Colourfulness	32.49	28.96	1.82	0.06
	Contrast	0.38	0.40	-1.9	0.07
	Sharpness	5.37	5.10	0.34	0.37
	Noise	0.67	0.96	-1.47	0.07

4.3 Implications

The findings in Table 4.1 indicate the fact that a gap exists between the visual quality of what hotel managers advertise and what traveler actually perceived. Hotel managers should be careful about the quality of the photos to be chosen for online marketing. The use of high quality photos, especially those polished by professional photographers, does not always result in a positive result. Because, when travellers' experience, is significantly different from their expectations, they are likely to have negative feeling [61]. Besides, the capability of the visual feature was also verified in the comparison between recent and prior photos (Table 4.2), which may reflect the quality differences in term of photo capturing devices. It would be beneficial for tourism managers to examine the sharpness and noise features of photos taken by different groups of travellers for insights into their photo taking preferences. Some travellers may like capturing high quality photos, while others do not care much about such aspect. Tourism marketing managers can incorporate high quality photo capturing devices as bonus gift or pool prizes into travel packages to promote the purchases by travellers who like taking quality photos of their trips. The proposed approach can help tourism managers in selecting suitable quality photos for their travel websites or assessing the existing websites in a quick and efficient way. Table 4.3 shows some consistency between visual quality of photos and reviewer's sentiment in case of hotel photos. A colourful and bright photo of hotel bedroom shared on social media would implicitly express the positive feeling of photo taker about the room, while a dark photo of a messy room would deliver the opposite message. Tourism managers will not only able to identify hotel features that attract tourists' attention, but also their

emotion experience, for deep insights into tourist's perception.

Generally, hotel managers are more likely to post higher quality photos in terms of *Brightness*, *Colorfulness*, *Contrast*, *Sharpness* and *Noise* than travellers. Photos posted recently have higher quality than previously in term of *Sharpness* and *Noise*. And last but not least travellers who are not satisfied with the hotel tend to post lower quality photos than those satisfied.

4.4 Summary

The visual quality of photos on online travel platforms plays an important role in influencing travellers' emotion and their travel intention and at the same time helps tourism managers find out which photos affect travellers decision making. This chapter approached the task of assessing hotel photos publicly available on the Internet. The dataset in our experience containing about 10,000 photographs with other additional demographic information such as traveller's location of origin, traveller's type such as (business, family, solo, couple, friends) as well as hotel stars ratings was also extracted. Due to the limitation of prior manual analysis approach, in this study, five visual features are introduced *Brightness, Colourfulness, Contrast, Sharpness* and *Noisiness* to objectively evaluate visual photo quality from this dataset. A photo that is taken at daytime it does not mean that has got better quality than a photo taken during the night. Thus the experiment examines day and night photos separately. For that purpose an SVM machine learning algorithm is adopted, to help with an automatic classification for a large number of photos in our data collection. The efficiency of this approach is demonstrated in an application on Melbourne hotels

and discovered the visual photo differences between traveller photos and management photos. This study supports hotel managers in developing influential marketing materials to gain more customers to their business.

Chapter 5

Conclusion and Future Work

Consumer-driven visual content such as photos can be found on a variety of social media platforms such as social network sites, portals, virtual communities, wikis, blogs and travel-related consumer portals [208, 99]. Photos posted during a trip or after travel present the same characteristics as textual social media content. They are fast and up to date, and as they are available everywhere, they have become the word of mouth of the digital age [83]. Analysing of these photographs provide a whole new opportunity in understanding customer experience and behaviour in the hotels, which is the key to effective strategic planning and decision making for hotel businesses. The increased interest for better understanding into travellers requirements, experience and behaviour from online visual data such as photographs in our case has made current tools and techniques inadequate to adapt to different situations. Using the tourism and hotel industry as an experiment, this thesis introduced new methods for advanced photo processing techniques and evaluated visual photo content and visual photo quality from online hotel photos, which are beneficial to researchers and practitioners in analysing large-scale visual data. Our research has accomplished following two areas:

1. *Visual Photo Content Assessment* - focuses on introducing a computational approach for automatic recognition of photo content that supports the analysis of travellers' interests of hotels. In the past photo, content analysis was carried out mainly manually, using people to analyse the photographs subjectively. This method was inefficient and time-consuming for large datasets. For that reason, to delivery efficiency in our experiment, we adopted a machine learning model trained from one of the biggest CNNs to date to evaluate visual photo content from online hotel photos. It is beneficial for hotel managers to access the photo content to identify customers needs and experience and help them develop better strategic planning and decision making.

2. *Visual Photo Quality Assessment* - focuses on introducing an automatic computational approach for extracting visual features which represent the photo quality. Due to the inefficient and laborious subjective photo quality approaches in the past, in this study, five visual features are introduced *Brightness, Colourfulness, Contrast, Sharpness* and *Noisiness* to automatically evaluate visual photo quality from online hotel photos. Photo quality analysis would supports hotel managers in developing better marketing materials as well as deeper understanding of what type of photos are more influential and make a better impact towards customer's perception.

5.1 Contributions

The main contributions of this thesis based on the theoretical and experimental results are presented as follows:

- ***Photo Content Analysis:*** Tourism and hotel industry is dealing with a tremendous amount of online visual data such as photographs posted from customers along their tips on the travel websites. This big visual data has a high potential for a new way of studying customers behaviour such as their interests and experience when they travel to the hotels. Unfortunately, due to the absence of people's ability to handle this massive amount of data, which in the past was mainly carried out manually, previously there was a lack of analysing these existing gigantic data resources accurately. This is probably due to the current approaches to photo recognition which are either subjective and time-consuming or lacking efficiency and make a significant use of computer power to solve even a simple task. Aiming to address above mentioned shortcomings, this thesis proposed a photo content recognition from online hotel photos based on a machine learning model trained from one of the biggest CNNs to date (Chapter 3). This technique offers an effective way of identifying customers preferences and interests as well as reveal their experience from their hotel stay. Practical efficiency of the proposed approach is demonstrated in an application of tourists in Melbourne hotels. The primary knowledge supports hotel managers to understand their customer needs and preferences better, as a consequence, help them develop sustainable hotel industries.

- ***Photo Quality Analysis:*** The massive amount of visual data find online, mainly the photos of potential visitors destinations have a significant influence towards customers decision making and the temptation of visiting that place. High-quality, professional images can add a whole new dimension to your website and marketing materials, thus, enhance the tourism and hotel business

performances. Previously, photo quality assessment was accomplished mainly manually where the photo quality was judged by people. The problem of this subjective approach is inefficient when it comes across large dataset like ours that we use here in this thesis. Therefore, it was essential developing a computational automatic way of objectively recognising the visual photo quality. We proposed five representative features to our datasets, which are helpful in reflecting the visual photo quality such as *Brightness, Colourfulness, Contrast, Sharpness* and *Noisiness* (Chapter 4). These five visual features allow for automatic identification of visual photo quality from our dataset of online hotel photo. The performance of the proposed visual features is demonstrated in an application of online photos from Melbourne hotels. The mined knowledge supports hotel managers to better understand which photos would be more suitable for their website and marketing materials and at the same time improve the experience and impact on customers regarding their businesses.

5.2 Future Work

Evan though various approaches were proposed in assessing the visual photo content and quality to address the customers behaviours, there still reminds some further research that it could be done such as improve the current techniques and using them in different tourism applications.

Because of the limited time of this thesis, some areas were left unexplored. Further research can be demonstrated in evaluation the visual content analysis in photos taken at restaurants and tourist attractions to further verify the capability of this approach in different scenarios. We focus on hotels in Melbourne but this research can be further

extended in different cities/countries, and then compare the results between various groups of travellers based on their country of origin or different continent etc. In Chapter 3, an already trained machine learning model was adopted. Further research can be carried out to use a specifically design machine learning model for the industry we are mainly exploring, for example, we can train a model using dataset only from photos in the hotels or hospitality industry and achieve even better performances.

Due to the limited scope of the thesis, in Chapter 4 only five representative visual features were introduced and tested. Further research can be carried out to identify other features for assessing the photos in different aspect such as aesthetics and emotional influence of the visual content to viewers. Experiments can also be carried out for photos taken at restaurants and tourism attractions to further verify the capability of the visual features in different scenarios.

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