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Various Image Classification Using Certain Exchangeable Image File Format (EXIF) Metadata of Images

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Abstract

Advances in digital imaging technology has led to a distinct feature in digital cameras nowadays. Not only that futuristic digital images could be obtained from taking pictures of astonish sceneries and objects, but metadata of digital images that is been called Exchangeable Image File Format (EXIF) are also been embedded in those image. EXIF metadata contains many and various kinds of features that represent the settings of the camera with a given value to it when the image was been taken. Thus, with a combination of certain EXIF metadata features with undisputed values could distinguish various kinds of image classification. From the findings through background studies on conducted researches and experiments, seven features of EXIF metadata, which are exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height with their certain given values could facilitate scenery and object image classification.

Keywords*: *Digital image, image classification, metadata, Exchangeable Image File Format (EXIF).

1. Introduction

Living in an era of endeavoring unprecedented rates of data is what we are dealing nowadays. For the last decade, studies in improving data storage devices and implementing ways to develop and gather data in the same time have shaped our technique in handling information whereby usually, data is being stored without any clarification or revision for later use (Keim et al., 2008). This is due to almost all industries, business, political and personals produces huge amount of data on daily basis (Keim et al., 2008, & Platt, 2000). The downside is that we are not being capable to utilize the data for decision-making process as fast as collecting and storing it. Nevertheless, in most situations, there is no value in raw data because people normally like to harvest information that accommodates in it (Keim et al., 2008).

Metadata is data about data (Kozak, 2014, Cortaville, 2013, Pesce, 2008, Gilliland, 2008, & Alvarez, 2004). This is similar to Siegel and Madnick's (1991) statement whereby metadata is data about interpretation, content, management, or reason of data where metadata could be as plain as a relational schema or as complex as information that describes the originator, deduction, elements, precision, and background of the discrete data items. However, according to the Australian Government Solicitor (AGS), metadata is personal information under the Privacy Act 1988 (Commonwealth (Cth)) (2015). Metadata is embedded in digital images by using a variety of mechanisms (Kozak, 2014 & Johnson et al., 2015). Pesce (2008) adds that metadata is normally being concealed from being presented to the user.

According to the Technical Standardization Committee on Audio/Video (AV) and Information Technology (IT) Storage Systems and Equipment (2002), smart phones and digital cameras that can produce Tagged Image File Format (TIFF) and Joint Photographic Experts Group (JPEG) image file format could provide Exchangeable Image File Format (EXIF) metadata to the images that had been captured by those digital image capturing devices. This is also being supported by Alvarez (2004) by

stating that many manufacturers of digital camera, such as Kodak, Canon, and Sony put the use of EXIF headers into practice, whereby in a TIFF file, the tags are privately defined, whereas in a JPEG file, the EXIF header is being stored in an "application segment". Puntti (What is EXIF Metadata) agreed with Alvarez's list of digital camera manufacturers and had added a couple more such as Nikon, Olympus, Epson, Sanyo, Ricoh, Casio, Toshiba, Fujifilm, Konica, Minolta, Pentax, Kyocera, and Panasonic manufacturers that can produce images with EXIF metadata.

However, Alvarez (2004) opposed by stating that not all digital cameras use or provide EXIF metadata or headers to the pictures taken by those such cameras. Apart from that, Pelski (2005) and Kozak (2014) agreed upon digital images of TIFF and JPEG file formats can store EXIF metadata. Despite of what had been mentioned by the Technical Standardization Committee on AV and IT Storage Systems and Equipment, Alvarez, Pelski, and Kozak above, Sun et al. (2002), Snavely et al. (2007), Smith et al. (2012), and Sumner (2014) stated that EXIF metadata are embedded on all digital images automatically by digital devices that capture the images.

EXIF is the standard way of image file storage that was been developed by the Japan Electronic Industry Development Association (JEIDA) towards storing image files as well as the metadata about the images that are been created by digital cameras (Kozak, 2014, Pelski, 2005, & JEITA, 2002). EXIF metadata contains many tags that among of them could define the size of the image, colour profundity, image resolution, image's date and time of creation, location of the capturing device when it captures the image, which uses Global Positioning System (GPS), description about the image, camera settings, and even thumbnail image (Kozak, 2014, Boutell & Luo, 2004a & 2004b, & Pesce, 2008). On top of that, Pesce (2008) also includes that in EXIF, there are hundreds of pre-defined tags for all information types. Pesca (2008) and Alvarez (2004) defined that certain custom tags of EXIF metadata can be manually added by the user.

EXIF metadata value can be very beneficial to photographers as it could allow them to capture, share, revise and improve their photography skills (Hingorani, 2016). A mixture of certain EXIF metadata can classify a category of image. However, according to Boutell and Luo (2004a & 2004b), the thought of using EXIF metadata of images to create image classification is not a new thing, as to there have been many researches using various kinds of image's EXIF metadata with different kinds of methods in classifying an image category.

The purpose of this paper is to suggest certain values of digital image's EXIF metadata features to distinguish the image classes of scenery and object. The image's EXIF metadata features that are involved are exposure time or shutter speed, f number (also known as f-number) or aperture, International Standards Organisation (ISO), flash, focal length, image width, and image height. From the stated image's EXIF metadata features, the potential of using them to manage in identifying scenery and object image has thoroughly yet been technically explored, but deem promising as towards exploiting the features base on literature research..

2. Background

Various kinds of researches had been conducted to identify different methods in classifying images (Boutell et al., 2003, Boutell & Luo, 2004a, Boutell & Luo, 2004b, Carson et al., 2002, Oliva & Torralba, 2001, Paek & Chang, 2000, Song & Zhang, 2003, Szummer & Picard, 1998, Vailaya et al., 1999, & Guo, 2011). Hingorani (2016) had identified four categories of EXIF tags, which are Focal Length, Shutter Speed, Aperture, and ISO to explore image's aesthetics from a photographer's point of view. The aim of the research was to manage and picturize images as actionable data for finer understanding of perspective, light, and exposure, which is beneficial for photographers.

Boutell and Luo (2004a) had point out two issues concerning image classification, which are indoor-outdoor classification and sunset detection that discloses EXIF metadata fields such as exposure time, flash, and subject distance. In Boutell and Luo's (2004a) research, a Bayesian network model is

engage to blend content-based and metadata cues in the likelihood domain, which degrades respectfully when specific metadata inputs are missing.

From the research that had been conducted by Boutell and Luo (2004a), it revealed that exposure time, flash, and subject distance are important cues. However, rooting from the extensive previous research of Boutell and Luo (2004a), an upgraded experimentation had been conducted by using Bayesian network to fuse diverse (content-based and metadata) cues in a robust fashion way in order to gain two new observations (Boutell & Luo, 2004b). The first observation was adding metadata to the content based cues, which then provides highest accuracies. The second observation was that the metadata cues alone could perform better than the content-based cues alone for certain applications, leading towards a system with high performance, yet requiring very little computational overhead. Thus, from the new research findings, the advantageous of incorporating metadata cues can be presume to generalize to other scene classification issues.

Guo (2011) used the features of flash, exposure time, aperture values, and ISO speed rating EXIF metadata to determine indoor and outdoor classification of digital images in order to organize photo collections. Apart from the EXIF metadata features, Guo (2011) also used colour features that were been collected by means of histogram, texture features that were been extracted by discrete wavelet decomposition, as well as structure of scenes that were been estimated by spatial envelope. Guo (2011) train the different classifiers by exploiting single feature, combination features, feature extraction strategies and various image resolutions in order to verify the best success rate of the classification.

Liu et al. (2005) explore the general statistical learning method constructed from boosting algorithm to perform image classification of indoor or outdoor, city or landscape, and to detect the image's proper orientation for photograph annotation and management. Liu et al. (2005) uses image content which are colour moment and edge direction histogram, as well as features from the EXIF metadata of the digital images to identify the classifications. The EXIF metadata that were been used are aperture value, CCD width, distance, date time, exposure bias, exposure program, exposure time, file data time, flash used, focal length, ISO equivalent, metering model, white balance, and Exposure Value (EV) (Liu et al., 2005).

Alvarez (2004) stated that digital images that contain EXIF headers could help the process of distinguishing between an authentic and altered picture. This could be done by checking on the EXIF headers whereby the EXIF header of a picture file would be lost if the picture file has been modified by using a picture editing software. On the other hand, a picture is possibly unaltered if the picture file contains its EXIF information (Alvarez, 2004). However, certain editing software such as Adobe Photoshop 6.0 and Lightroom have the capability of preserving the EXIF header data of metadata during the editing process (Cortaville, 2013, & Alvarez, 2004). Photoshop for example, inserts version information into the comment to make it easy for spotting edited files (Alvarez, 2004).

Platt (2000) had used either one or a combination of two types of EXIF metadata features to cluster digital images into albums by using a tool named AutoAlbum. The first category consist of time and date creation metadata of the digital image. The second category consist of the order in which the photos were taken, or in other words, the file name metadata of the digital image. The image clustering algorithm for the first category, named time-based clustering, only uses the creation time and date metadata while ignoring other metadata of the image. Clustering with this category gives extremely well results. However, if the camera, download or storage method does not preserve the creation time and date metadata, then the second category of clustering, named content-based clustering, will be used. Both time-based and content-based clustering methods can also be combined to produce smaller clusters of images (Platt, 2000).

By combining the analysis of photo's image and EXIF metadata of GPS coordinates and timestamp through the usage of a computerized mapping system named Distance Diagnostic and Identification

System (DDIS), Xin (Xin, 2009) has proven that the system enables its users to track or map pests and plant diseases through time and space location. The EXIF metadata of GPS coordinates and timestamp represent the location and time respectively of where and when was the picture been taken. As such, information about what, when and where can be acquired from geo-tagged images (Xin, 2009).

From the literature stated above, various kinds of EXIF metadata were been used with different methods implementation to distinguish diverse types of image classifications. However, there are still many kinds of image's EXIF metadata or a combination of them that are yet to be explored.

3. Methodology

This study aims to distinguish between scenery and object-based digital image classification through the usage of seven kinds of EXIF metadata, which are exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height. From the literature experiments that had been conducted, few out of these seven features had represented the classification of scenery images.

We would assume that object-based images have the opposite EXIF metadata values from the scenery-based images. For example, people will normally capture object photos with their camera's flash on (Sun et al., 2006, Imaging CH, 2013, & Adelsberger, 2008), whereas photos of scenery are normally been taken with no flash as distant background of a scenery may be poorly lit by the flash compared to the foreground or object-based scenarios (Sun et al., 2006, & Adelsberger, 2008). Thus, this paper could possibly define scenery images with a given value of those seven features and by implementing opposite values onto those seven features to identify object images, provided those images come with all seven features in their EXIF metadata.

3.1 EXIF metadata retrieval

There are a couple of EXIF specifications on digital image file such as the definition of format version, digital image data specifications, image data basic structure, tags or header, segments of JPEG marker and data recording specifications (Technical Standardization Committee on AV & IT Storage Systems and Equipment, 2002). Figure 1 illustrates a captured digital image and Figure 2 until Figure 6 illustrate the EXIF metadata that are been stored under the "Properties" window panel of the captured digital image by using Windows 7 Operating System.

Figure 1: The captured digital image.

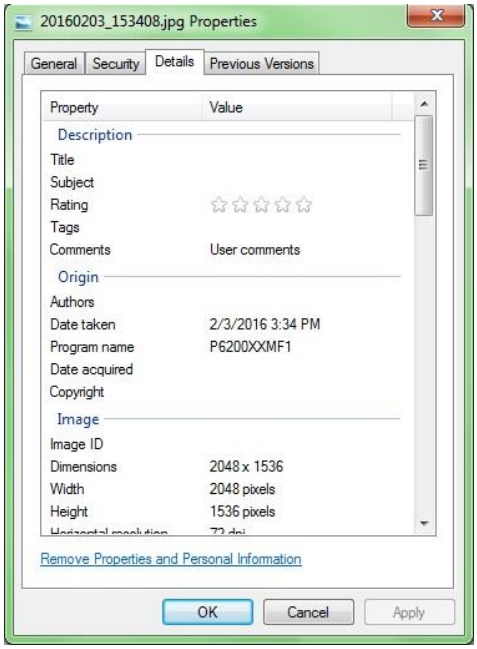

Figure 2: Stored EXIF metadata under the "Properties" window panel that shows the description and origin metadata of the digital image.

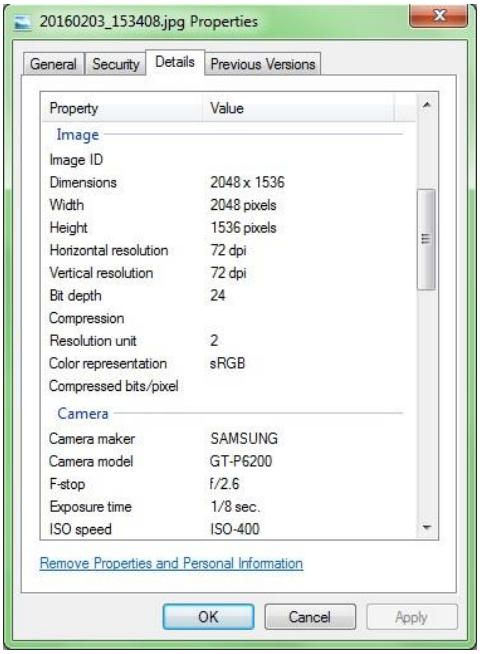

Figure 3: The continual image of stored EXIF metadata under the "Properties" window panel that shows the image metadata of the digital image.

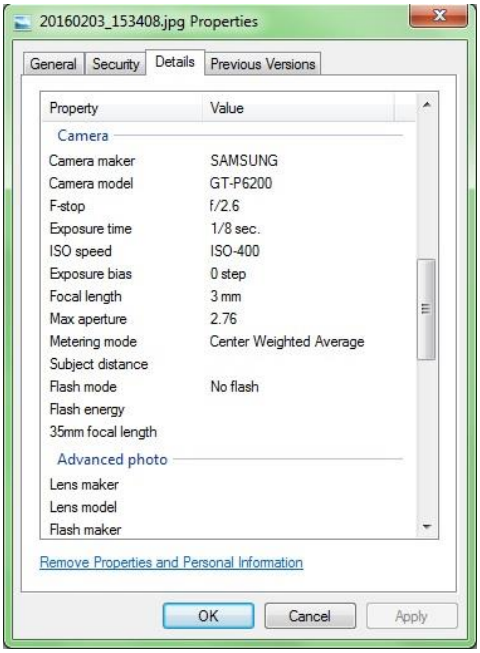

Figure 4: The continual image of stored EXIF metadata under the "Properties" window panel that shows the camera metadata of the digital image.

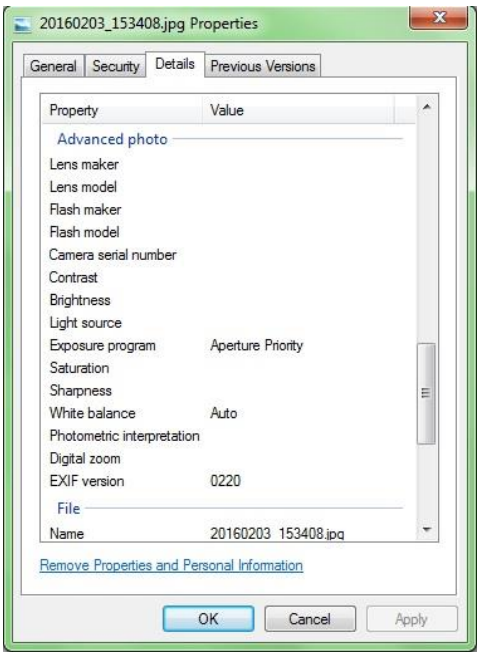

Figure 5: The continual image of stored EXIF metadata under the "Properties" window panel that shows the advanced photo metadata of the digital image.

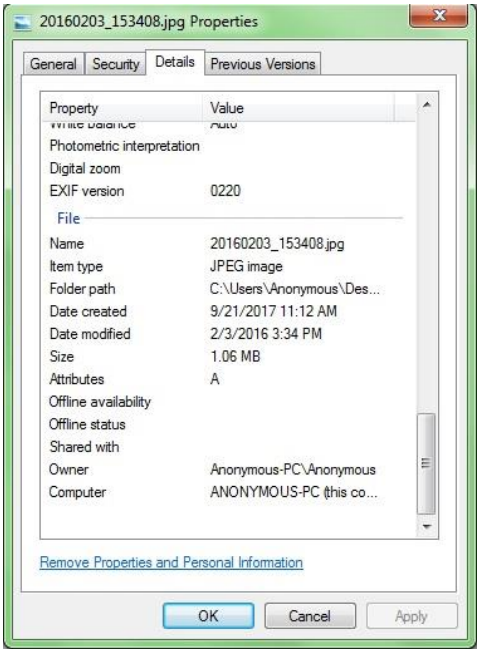

Figure 6: The continual image of stored EXIF metadata under the "Properties" window panel that shows the file metadata of the digital image.

3.2 The seven features of EXIF metadata

Guo (2011) indicated that through the experiment that had been conducted, a total amount of 42.30% out of 2790 images contain all four EXIF metadata of exposure time, aperture, ISO, and flash with a percentage of 91.87%, 53.81%, 76.66%, and 92.11% respectively. In addition to that, we add another three features of EXIF metadata that are also usually available in images, which are focal length, image width and height (JEITA, 2002). Thus, the seven features of EXIF metadata that could depict scenery and object images are exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height. Each of them defines different purpose and value unit.

The process of time duration from opening to closing of the shutter represents the exposure time or shutter speed of a camera (Guo, 2011, Liu et al, 2005, Cortaville, 2013, Kozak, 2014, & McHugh, 2016). The recorded time for exposure gives the exposure time or shutter speed value in seconds (JEITA, 2002). Exposure time and shutter speed refer to the same notion, where a slower shutter speed or the larger the value of exposure is, the longer the time of light exposure, and vice versa. In other words, the camera's shutter controls when the camera sensor will be open or closed to incoming light from the camera lens, creating exposure time or shutter speed values which depict the duration of light exposure that is been controlled. Therefore, exposure time or shutter speed refers to the time duration of light been permitted to enter the camera and reach the sensor or focal plane (Guo, 2011, Liu et al, 2005, Cortaville, 2013, Kozak, 2014, & McHugh, 2016).

F number or aperture setting controls the area over which light can pass through the camera lens in a fixed amount of time (McHugh, 2016, Kozak, 2014, & Guo, 2011). The f number or aperture value is the focal length divided by the effective aperture diameter (Liu et al, 2005, & Cortaville, 2013). F number or aperture settings can be counterintuitive (McHugh, 2016, & Guo, 2011) because the opening area increases as the f number decreases (McHugh, 2016). Simply put, if the exposure time is constant, the bigger the aperture is, the greater amount of light can reach the sensor, and on the contrary, the smaller it is, the less will be absorbed (Guo, 2011).

Cortaville (2013) stated that before the immerging of digital photography, ISO was a universal standard for film sensitivity to light that has been set by International Organization for Standardization (Liu et al., 2005). ISO value can now be adjusted from shot to shot, giving much

more usable and flexible process towards the photographer (Cortaville, 2013). ISO speed ratings indicates the ISO Latitude and ISO Speed of the camera or input device as specified in ISO 12232 (name of the standard for measuring the sensitivity of a Digital Still Camera (DSC) when specifying light sensitivity of a high-speed camera) (JEITA, 2002). ISO speed controls the sensitivity of the camera's sensor to a given amount of light, which is necessary needed to produce a picture (McHugh, 2016, & Guo, 2011).

When capturing certain images, flash is been used as a momentary artificial light that acts as a source of illumination (JEITA, 2002, McHugh, 2016, & Guo, 2011). The EXIF metadata of flash indicates the status of flash whether it was been used or not when the image was shot (JEITA, 2002, & Liu et al., 2005).

When a subject is at focus point, the focal length is the actual focal length of the lens (JEITA, 2002, Liu et al., 2005, & Cortaville, 2013) and it is been measured by the distance between the lens of where the light enters and the image sensor (Cortaville, 2013, & Hingorani, 2016). Value of the focal length is usually been stated in millimeter (mm) (JEITA, 2002, Hingorani, 2016, & Cortaville, 2013). In other words, focal length of a camera's lens verifies its angle of view, and how much does for a given photographic position will the subject be magnified (McHugh, 2016).

The image size of a graphic image file is been measured in pixels (JEITA, 2002, & McHugh, 2016). The EXIF metadata value of image width indicates the measurement number of pixels in the width scale of the image. The image's width is usually been listed first before the height. On the other hand, the EXIF metadata value of image height indicates the measurement number of pixels in the height scale of the image (JEITA, 2002).

This shows that for each of the seven EXIF metadata features has different definition that serves for different purpose and comes with a certain measurement value unit. Thus, with the correct measuring threshold or range value of the seven EXIF metadata features could possibly portray the classification of scenery and object images.

3.3 Values for scenery and object classification

It is presume that with a certain range of values derived from the EXIF metadata of exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height of a digital image could identify the image either being a scenery or an object-based image.

According to Guo (20110, very large or long exposure time or shutter speed could be used for taking a picture of a star orbit. On the other hand, it could be very short for capturing a clear picture of a fast moving object. This is because, the larger the value of exposure is, the longer the lights will be captured, which suits situation with bad illumination. However, small exposure time is perfect for a brighter scene. Images with exposure time of less than 0.016 sec. are more likely to be of outdoor scenes. Natural brightness from the sunlight is much scintillating than artificial light (Guo, 2011). This ensures Liu et al. (2005) to also agree with the fact that lower exposure time or shutter speed could determine a picture with natural environmental lighting features, like an outdoor scenery picture. Standard values for shutter speeds are within the range of 1/1000sec (second) for short exposures, moving on to 1/500sec, 1/250sec, 1/125sec, 1/60sec, 1/30sec, 1/15sec, 1/8sec, 1/4sec, 1/2sec, and 1sec for long exposures (Hingorani, 2016, & Cortaville, 2013).

F number or aperture values are generally considered to be useful because they get smaller when people take photos of outside scenery and bigger for inside or closed location like in a room (Guo, 2011). Due to their values and settings and can be counterintuitive (McHugh, 2016, & Guo, 2011), large aperture number which represents small aperture opening is suitable for taking sceneries of natural lighting environment, and vice versa (Liu et al., 2005, Guo, 2011, & Cortaville, 2013).

Aperture scope or the size of the lens opening can be changed accordingly and the unit for it is been demonstrated as f number, or aperture or F-stop in the form of for example, f8 or f/8.

f32 (or f/32), f22 (or f/22), f16 (or f/16), f11 (or f/11), f8 (or f/8), f5.6 (or f/5.6), f4 (or f/4), f2.8 (or f/2.8), f2 (or f/2), and f1.4 (or f/1.4) are the range of aperture scope or the size of lens opening that lies within (Hingorani, 2016, & JEITA, 2002). The range scale that is nearby to f2 represents large aperture, f8 represents medium aperture and f22 represents small aperture.

The f number in each scale, allows half or double as much light into the digital camera, for example, f16 allows only half as much light in as f11 and f2.8 lets double as much light in as f4. Small F-stop number or value represents large lens opening or aperture which creates a shallower depth of field that produces a lesser amount of focus in a picture (Davies, 2016). In other words, this setting would be suitable for capturing object images.

High ISO value allows people to take pictures in a lower light environment or with small aperture value (Guo, 2011, & Cortaville, 2013). However, noise is usually been generated on images that are been taken with high ISO values (Guo, 2011, Cortaville, 2013, & Hingorani, 2016). Thus, high ISO value is suitable for scenes that are low of illumination which are likely to be indoor scenes or object images (Guo, 2011, & Cortaville, 2013). This makes low ISO value being suitable for outside or scenery images as lower ISO values are less sensitive to light (Cortaville, 2013). ISO standard values ranges from ISO 50, to ISO 100, ISO 200, ISO 400, ISO 800, ISO 1600, ISO 3200, ISO 6400, ISO 12800, and ISO 25600, whereby ISO 50 represents the low value of ISO and ISO 25600 represents the high value of it (Hingorani, 2016).

Guo (2011) showed a graph representing the percentage of flash firing that was been used for different scenes gives different values whereby, 60% of indoor images were been captured with with no flash and 40% with flash. However, there is a huge gap for the outdoor images, whereby around 95% of the images were been taken without flash and 5% with flash. Therefore, most scenery images does not requires flash utilization, and usually flash is being used to capture object-based images.

According to McHugh (2016), wide angle of lens view has short focal length value, and telephoto lens or narrow angle of lens view has longer corresponding focal length value. A wide angle lens can be used for exaggerating depth and relative size in a photo, while telephoto lens is for enlarging distant subjects and normalizing the size and distance difference between near and far objects, which can make the depth of field appear more shallow (McHugh, 2016). Thus, lower focal length value that gives a wider field of view would be suitable for scenery images and high focal length value that gives a narrow field of view would be acceptable for object images (Hingorani, 2016).

O'Reilly (n.d.) mentioned that horizontal view represents capturing landscape images (Advice Note 01/11, 2011), while vertical view depicts portrait pictures. In other words, an image that has width value that is higher than its height value or height value that is lower than its width value could illustrate a scenery picture. On the other hand, an object image could be derived from an image that has width value that is lower than its height value or height value that is higher than its width value.

Thus, with a proper given value to all of these seven EXIF metadata features could classify the scenery and object images.

4. Discussion

Findings and results of executed experiments had demonstrated various image classification using different features of EXIF metadata and methods to achieve their objectives. Thus, from the literature reviews that had been studied, classification of scenery and object images could be achieved by extracting values of exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height from the EXIF metadata of the images. Scenery images could be

derived from slow exposure time or shutter speed, high f number or aperture value, high ISO speed, no flash, short focal length, and width value that is higher than its height value. Whereas, fast exposure time or shutter speed, low f number or aperture value, low ISO speed, flash been used, long focal length, and height value that is higher than its width value could represent the classification of object-based images.

5. Conclusion and Future Work

Through the various kinds of image classification that exist, images of scenery and object classification by using EXIF metadata is just another experimental tool that could expend the research in solving scene classification problems. With the given categorical values of the seven features, which are exposure time or shutter speed, f number or aperture, ISO, flash, focal length, image width, and image height could enable the scenery and object image classification. Future work on finding the best linear combination for the selected features and boosting certain algorithm to choose the best robust combination of features for the scenery and object classification are yet to be conducted in order to obtain the efficiency of the whole research.

References

Adelsberger, R., Ziegler, R., Levoy, M., & Gross, M. (2008). Spatially adaptive photographic flash. *ETH, Department of Computer Science.*

Advice Note 01/11. (2011). Photography and photomontage in landscape and visual impact assessment. *Note A, Charles Darwin House, 12 Roger Street, London WC1N 2JU, United Kingdom.*

Alvarez, P. (2004). Using extended file information (EXIF) file headers in digital evidence analysis. *International Journal of Digital Evidence, 2(3), 1-5.*

Australian Government Solicitor (AGS). (2015). Metadata is 'personal information' under the Privacy Act 1988 (Cth). *Express Law Fast Track Information for Clients, Australia.*

Boutell, M., & Luo, J. (2004a). Bayesian fusion of camera metadata cues in semantic scene classification. *InComputer Vision and Pattern Recognition, 2004, CVPR 2004, Proceedings of the 2004 IEEE Computer Society Conference on 2004 Jun 27, 2, 623-630, IEEE.*

Boutell, M., & Luo, J. (2004b). Photo classification by integrating image content and camera metadata. *InPattern Recognition, 2004, ICPR 2004, Proceedings of the 17th International Conference on 2004 Aug 23, 4, 901-904, IEEE.*

Boutell, M., Luo, J., & Gray, R. T. (2003). Sunset scene classification using simulated image recomposition. *InMultimedia and Expo, 2003, ICME'03, Proceedings, 2003 International Conference on 2003 Jul 6, 1, 37-40, IEEE.*

Carson, C., Belongie, S., Greenspan, H., & Malik, J. (2002). Blobworld: Image segmentation using expectation-maximization and its application to image querying. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 24(8), 1026-1041.*

Cortaville, S. (2013). Portrait photography: Art and techniques. *The Crowood Press Ltd., Ramsbury, Marlborough, Wiltshire, England, United Kingdom.*

Davies, J. (2017). The basics of photography. Jeff Davies Picture Gallery. Available: http://www.jeffdavies.luxipics.com/. Accessed: October 9, 2017.

Gilliland, A. J. (2008). Setting the stage. Introduction to metadata. *The Getty Research Institute, Los Angeles, United States of America, 3.*

Guo, F., Bossard, L., & Gool, L. V. (2011). Indoor outdoor image classification. *Bachelor Thesis.*

Hingorani, M. (2016). Into the technicalities of photography: An EXIF data exploration. *University of California, Santa Barbara, California, United States of America.*

Imaging CH. (2013). Reflectance transformation imaging: guide to highlight image capture v2.0. *Cultural Heritage Imaging, San Francisco, California.*

Johnson, J., Ballan, L., & Fei-Fei, L. (2015). Love thy neighbors: Image annotation by exploiting image metadata. *InProceedings of the IEEE International Conference on Computer Vision, 4624-4632.*

Keim, D., Andrienko, G., Fekete, J. D., Gorg, C., Kohlhammer, J., & Melançon, G. (2008). Visual analytics: Definition, process, and challenges. *Lecture Notes in Computer Science, 4950, 154-175.*

Kozak, K. (2014). Management of large sets of image data: Capture, Database, Image Processing, Storage, Visualization.

Liu, X., Zhang, L., Li, M., Zhang, H., & Wang, D. (2005). Boosting image classification with LDA-based feature combination for digital photograph management. *Pattern Recognition, 38(6), 887-901.*

McHugh, S. T. (2016). Understanding photography: Core concepts and techniques with digital image capture. *Cambridge in Colour.*

Oliva, A., & Torralba, A. (2001). Modeling the shape of the scene: A holistic representation of the spatial envelope. *International Journal of Computer Vision, 42(3), 145-175.*

O'Reilly, S. Forewords. (n.d.). The Research into Use Programme (RIU), NR International. *Park House, Bradbourne Lane, Aylesford, Kent, ME20 6SN, United Kingdom.*

Paek, S., & Chang, S. F. (2000). A knowledge engineering approach for image classification based on probabilistic reasoning systems. *In Multimedia and Expo, 2000, ICME 2000, 2000 IEEE International Conference on 2000, 2, 1133-1136, IEEE.*

Pelski, S. (2005). Oracle interMedia user's guide. *Oracle interMedia Documentation, Nashua, New Hampshire 03062, United States of America.*

Pesce, L. (2008). Document metadata, the silent killer. *SANS Institute InfoSec Reading Room.*

Platt, J. C. (2000). AutoAlbum: Clustering digital photographs using probabilistic model merging. *Incbaivl, 96-101, IEEE.*

Puntti, T. (2017). What is EXIF Metadata. Available: http://www.slrphotographyguide.com/what-is-exif-metadata/. Accessed: September 4, 2017.

Siegel, M. D., & Madnick, S. E. (1991). A metadata approach to resolving semantic conflicts. *Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America.*

Smith, M., Szongott, C., Henne, B., & Von Voigt, G. (2012). Big data privacy issues in public social media. *InDigital Ecosystems Technologies (DEST), 2012 6th IEEE International Conference on 2012 Jun 18, 1-6, IEEE.*

Snavely, N., Seitz, S. M., & Szeliski, R. (2008). Modeling the world from internet photo collections. *International Journal of Computer Vision, 80(2), 189-210.*

Song, Y., & Zhang, A. (2003). Analyzing scenery images by monotonic tree. *Multimedia Systems, 8(6), 495-525.*

Sumner, R. (2014). Processing raw images in matlab. *Department of Electrical Engineering, University of California Sata Cruz, United States of America.*

Sun, J., Li, Y., Kang, S. B., & Shum, H. Y. (2006). Flash matting. *InACM Transactions on Graphics (TOG), 25(3), 772-778, ACM.*

Sun, Y., Zhang, H., Zhang, L., & Li, M. (2002). MyPhotos: a system for home photo management and processing. *InProceedings of the Tenth ACM International Conference on Multimedia, 81-82, ACM.*

Szummer, M., & Picard, R. W. (1998). Indoor-outdoor image classification. InContent-Based Access of Image and Video Database, 1998. *Proceedings, 1998 IEEE International Workshop on 1998 Jan 3, 42-51, IEEE.*

Technical Standardization Committee on AV & IT Storage Systems and Equipment. (2002). Exchangeable image file format for digital still cameras: EXIF version 2.2. Japan Electronics and Information Technology Industries Association (JEITA), CP-3451.

Vailaya, A., Figueiredo, M., Jain, A., & Zhang, H. J. (1999). Content-based hierarchical classification of vacation images. *InMultimedia Computing and Systems, 1999, IEEE International Conference on 1999 Jul, 1, 518-533, IEEE.*

Xin, J. (2009). Tracking pests and plant diseases using geo-tagged digital images.