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automatic image annotation, image tagging, metadata

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ENCAPSULATION OF IMAGE METADATA FOR EASE OF RETRIEVAL AND MOBILITY

Abstract

Increasing proliferation of images due to multimedia capabilities of hand-held devices has resulted in loss of source information resulting from inherent mobility. These images are cumbersome to search out once stored away from their original source because they drop their descriptive data. This work, developed a model to encapsulate descriptive metadata into the Exif section of image header for effective retrieval and mobility. The resulting metadata used for retrieval purposes was mobile, searchable and non-obstructive.

1. INTRODUCTION

Today's technology centres on multimedia capabilities of hand held devices driven by the Internet and social network. According to a survey carried out by Pew Research centre in 2015, 64% of Americans own a smartphone (Smith, 2015). Other studies projected that 69.4% of global population would use mobile phone by the year 2017 (*Smartphone Users Worldwide Will Total 1.75 Billion in 2014*, 2015). It is not a surprise that cell phones are as common in South Africa and Nigeria as they are in the United States according to the statistics of a survey conducted by the Pew Research Centre in 2014 (*Pew Global*, 2016; *16 mobile market statistics you should know in 2016*, 2016). The number of Nigerians that own cell phones continues to grow yearly. The monthly subscriber statistics (Figure 1), for the Nigerian market for the period of January to March 2017, showed that 154,467,198 lines were active out of the 240,008,026 connected lines in Nigeria (*Monthly Subscriber Data*, 2016). With a population of about 190 million as at March 2017 (*World Population Review*, 2017), this means that "practically" everyone in Nigeria owns a mobile phone and this makes Nigerian

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the highest mobile phone users in Africa. A report by (*Internet World Stats, Usage and population Statistics*, 2016) showed that 92.7 million Nigerians were Internet Users as at November 2015 as shown in Figure 2. The summary of the survey by (*Numbers, Facts and Trends Shaping Your World*, 2015), clearly shows that as at the time of the survey, 89% of the respondents who owned cell phones, used the cell phone firstly for sending text messages and secondly for capturing multimedia files. As the volume of these multimedia files owned by individuals continues to grow daily, with 52% of Nigerians being Internet users as at 30th September 2015 (*Internet World Stats. Usage and population Statistics*, 2016), a lot of these multimedia files are uploaded to Facebook, LinkedIn, Twitter, Instagram and other Social network sites, using their mobile devices (Strydom, 2015; Chaffey, 2016). The tendency is to get to a point where owners and users of multimedia files are 'lost' when searching for a particular file or a file that has some particular information.

	OPERATOR	Mar '17	Feb '17	Jan '17	Dec '16
Connected Lines	*Mobile (GSM)*	235,941,553	235,532,689	234,599,704	231,601,485
	Mobile (CDMA)	3,586,095	3,586,095	3,586,095	3,586,095
	Fixed Wired/Wireless	340,895	340,566	340,465	352,045
	VoIP	139,483	126,962	116,647	59,236
	Total	240,008,026	239,586,312	238,642,911	235,598,861
Active Lines	*Mobile (GSM)*	151,999,197	153,661,547	154,660,446	154,124,602
	Mobile (CDMA)	217,566	217,566	217,566	217,566
	Fixed Wired/Wireless	152,500	151,500	151,088	154,513
	VoIP	97,935	89,871	84,447	33,099
	Total	154,467,198	154,120,484	155,113,547	154,529,780
	Teledensity	108.91	110.09	110.80	110.38

Fig. 1. NCC Mobile line Statistics January to March 2017 (*Monthly Subscriber Data,* 2017)

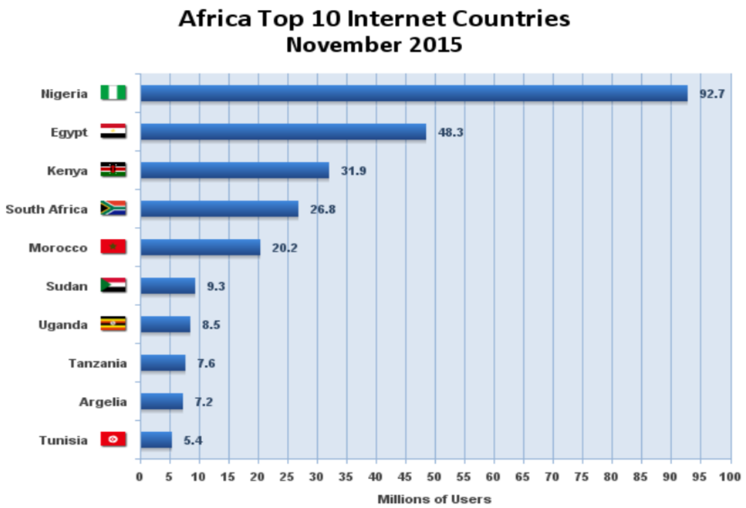

Fig 2. Africa Top 10 Internet Countries (Internet World Stats. Usage and population Statistics, 2016)

Given the volume of these images it will be cumbersome and time consuming to manually search through folders containing thousands of digital images. Some online photo development/social network companies (Facebook®, Ofoto) allow owners of photographs to manually add captions/annotations to their photos, however these captions are viewable but most often, not searchable (Kustanowitz & Shneiderman, 2005; Jaimes, 2006), because once the picture is downloaded from the Internet or the picture is removed from its source, most times it loses its caption and annotation. The loss of caption/annotation is because the annotation for such images, which were manually entered, where external to the images and were lost, as soon as the images left their source(s). A simple annotation on an image file has been reported as a method of enhancing information search (Rodden & Wood, 2003; Jaimes, 2006; Gozali, Kan & Sundaram, 2012), but the question is where such annotations are stored. The possibility of organising and 'labelling' image files can give rise to searchable multimedia data as well as enhance their usefulness (Wenyin et al., 2001; Ames & Naaman, 2007). With an all-encompassing approach, it is therefore essential that an image, if possible, should "move" with its annotation via its metadata. Image metadata are critical as they describe and manage digital images and also provide the most relevant and correct related data about that image. Metadata makes the visual content of an image easily accessible by human language terms and machine readable codes (*IPTC Photo Metadata Standard*, 2015).

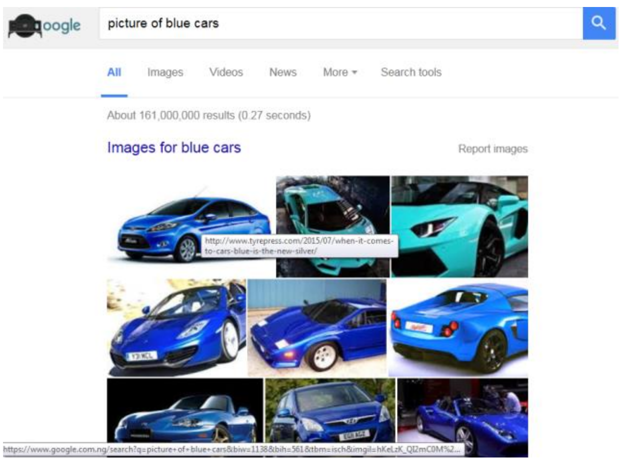

Fig 3. A snapshot of Google search with some of the results displayed (Google, 2017)

Consider Figure 3 that shows a snapshot of a Google search for "picture of blue cars"; the search fetched a number of pictures of blue cars. From the original source, it is obvious that some of the images had 'blue' appended to the filename as descriptive metadata. As soon as the picture is downloaded from the Internet it loses the 'blue' in the name, thereby losing part of its metadata.

Figure 4 shows a folder in a system where some of the images have been saved. A search on the system for “blue car” will not retrieve all the images, because the metadata for the images where external to the images and where lost, as soon as the images left their source(s). It is therefore significant that all images, if possible, “move” with some of its descriptive metadata. The aim of this work is to encapsulate descriptive metadata within an image for ease of identification, retrieval and mobility.

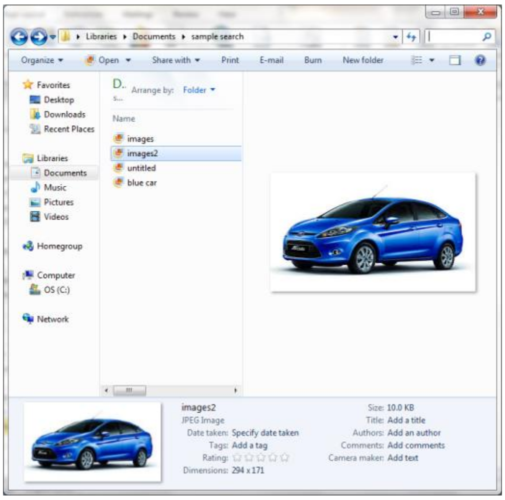

Fig 4. A snapshot of the folder containing the downloaded images from the Google search

1.1. Image Annotation

Image annotation refers to the various ways in which additional information is added to an existing image file, to give more information about the image file. Several approaches have been explored in information insertion and extraction from image files. Some of these approaches were based on imposing additional information layer on the image based on human or machine translation of these files (Kustanowitz & Shneiderman, 2005), such as the tagging of a person in a picture in Facebook. Annotation techniques can be grouped into three categories: Manual, Semi-Automated, and Automated, each with its own advantages and disadvantages (Hanbury, 2008; Zhang, Islam & Lu, 2012).

Manual annotation of image files has been shown to be the traditional method of annotating images and these annotations are usually stored in a database for ease of image retrieval, however, these annotations may not capture all the content of the image (Jeon, Lavrenko & Manmatha, 2003). Furthermore the information added depends greatly on the human annotator and his interpretation because it entails a human looking at each image and assigning the annotations as understood by him (Ivasic-Kos, Pobar & Ribaric, 2016).

The semi-automated image annotation approach starts with a manual process and then goes through annotations and extracts higher-quality, searchable meta-data, which it then re-associates with the picture. Wenyin et al. (2001) proposed a strategy for semi-automatic annotation in an image database system which depends on the user's interaction to provide an initial query and feedback and the system's capability for using these annotations as well as image features in retrieval to annotate the images in the database. In other to retrieve images using text, the images must be labelled or described in the surrounding text and since manual or semi-automatic method for providing image annotation can be a tedious and expensive task, especially when dealing with a large number of images, automatic image annotation has appeared as a solution (Ivasic-Kos, Pobar & Ribaric, 2016).

The goal of automatic image annotation, given an input image, is to assign a few relevant text keywords to that image which reflects its visual content (Makadia, Pavlovic & Kumar, 2008), while utilising the images' content to assign a richer, more relevant set of keywords. Automatic annotation of images was done within the digital camera as at the time the image was captured, by applying the date, time and GPS stamps, with date and time being the most common (Kustanowitz & Shneiderman, 2005). This approach embedded these technical annotation in the image but did not add any text that could describe the content of the image itself.

Some region-based approaches to automatic annotation by (Lavrenko, Manmatha & Jeon, 2003; Feng & Lapata, 2008; Weston, Bengio & Usunier, 2010) associated words with image regions. More specifically, they assumed that an image is segmented into regions and that image features were computed over each of these regions. Therefore, given a set of training images with annotations, probabilistic models allowed them to predict the probability of generating a word given the features computed over different regions in an image and then use the outcome for automatic image annotation of any new image.

However, one of the first approaches towards automatic image annotation proposed by (Mori, Takahashi & Oka, 1999), was the co-occurrence model that was based on the global features of an image. The annotation approach collected co-occurrence counts between keywords used for image annotation as well as image features and used these keywords to predict annotations for new images. (Duygulu, Barnard, Freitas & Forsyth, 2002) modified this approach by treating image regions and keywords as a bi-text to construct an image region-word dictionary. They represented images by a group of blobs (related region), and then translated the blobs into a set of keywords. These keywords were then used to annotate a new image. A snapshot of their result is presented in Figure 5 which shows the various 'blobs' and the keyword assigned to them.

Fig. 5. A snapshot of the result from Duygulu *et al.* (Duygulu et al., 2002)

(Wang, Zhang, Jing & Ma, 2006) proposed a global-feature based approach which searched for semantically and visually similar images on the Web, mined annotations from their descriptions and then assigned them to a query image. A key idea behind these approaches is to find the images most similar to the test or query image and then use their shared keywords for annotation. In an alternative global approach, (Makadia, Pavlovic & Kumar, 2008) proposed baseline methods for image annotation which are built on the assumption that images similar in appearance are likely to be annotated with similar sets of keywords, therefore they treated image annotation as a process of transferring keywords to an image from its nearest neighbours.

More recently, (Kuric & Bielikovan, 2015) proposed a method that combined global and local features in the process of automatic image annotation, to retrieve the best results during a search. The combination was more suitable to represent complex scenes and events categories because global and local features provide different kinds of information. The segmentation process, which was called "keypoint extraction" is closely related to edge detection. The goal was to obtain annotation for extracted segments of the target image and to estimate probability for each annotation.

Most of the approaches presented assigned annotations that either obstruct the view of the image or store these annotations as indexes outside the image, such that if the image left its source, it may need to be re-annotated. Hence, the importance of letting an image 'move' with its annotation. The approach proposed and implemented in this research work was to encapsulate image annotation (descriptive data) / metadata within the image, such that the information is non-obstructive, searchable and most importantly 'mobile'. To achieve this, the high level feature of JPEG image files especially the user text tags will be updated with descriptive text which portrays some of the actual content of the file.

2. METHODOLOGY

To ensure that there is no disconnect between descriptive data of a digital image and the digital image itself, the National Information Standards Organisation (NISO) developed several principles for encoding important descriptive metadata directly in the digital image files themselves alongside the several technical metadata that are usually stored as at the time of capture of these digital images (National Information Standards Organization, 2004, 2015). This would create a digital image file that is really self-describing because such images would store additional details (metadata) within itself and move about with such details. There are several standards that guide the capture and creation of image metadata, some of which are International Press Telecommunications Council (IPTC) Information Interchange Model (IIM), Extensible Metadata Platform (XMP) (*Extensible Metadata Platform (XMP)*, 2014) and Exchangeable Image File Format (EXIF). For the purpose of this research work, the EXIF standard was adhered to.

2.1. Exchangeable Image File Format (EXIF)

The EXIF standard was created by the Japan Electronics and Information Technology Industries Association (JEITA) to standardise the way digital/electronic devices that can be used to capture digital image, format and record image metadata at the time of the image capture (Japan Electronics and Information Technology Industries Association, 2002). Since its establishment, the EXIF standard has become the regular standard for formatting and storing digital image metadata therefore, this format is found on almost all digital imaging devices. Consequently, EXIF is typically used to store technical metadata such as the name of camera used for image capture, where obtainable, the camera settings used, the exact time and date of image capture, image size, among other technical metadata. In summary, EXIF specification specifies the guidelines that should be followed when recording image metadata in files. It also specifies the structure of digital image files, the user tags allowable and their management (Japan Electronics and Information Technology Industries Association, 2002). Digital Image formats such as JPEG and TIFF have segments in their header section, reserved for storing the image metadata.

2.2. Encapsulation steps

To achieve a more useful image file, this research work, encapsulated image descriptive metadata in the header section of a supplied image by modifying the author, title, keywords, and comment tags sections in the image header. Figure 6 shows the simple flow-model used to encapsulate metadata in JPEG files. The flow-model uses the descriptive metadata that were recognised using the steps proposed by (Woods, 2017). These metadata were stored in a text file with definitive delimiters that separate the four tags to be updated.

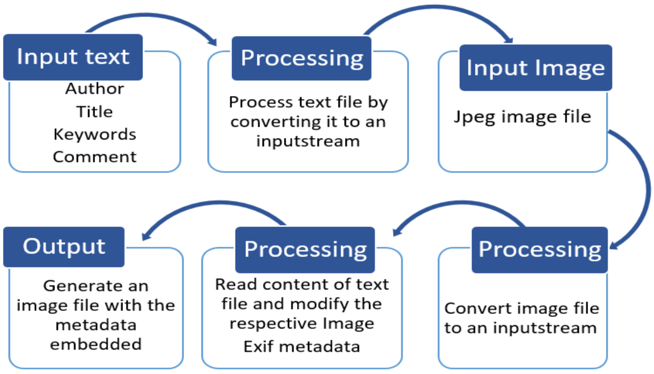

Fig. 6. Steps for metadata encapsulation

From figure 6 we note that firstly, the text file containing the intended metadata for a JPEG file is loaded. A sample of the content of this file is shown in Figure 7. The metadata are delimited by '&&' and are for updating four different segments in the Exif section of the image file. The first delimited string is intended to be used to update the **AUTHOR** tag; this is followed by the string for the **TITLE** tag, then the string for the **KEYWORDS** tags, and lastly the string for the **COMMENT** tag. The content of this text file is processed to extract the 4 strings for the different sections of the Exif tags by temporarily storing the extracted strings in four different variables.

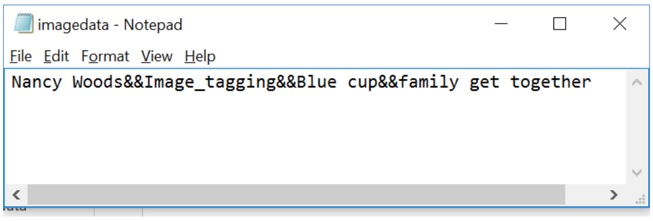

Fig. 7. Sample text file

Next, the JPEG image file that has the metadata is then loaded, converted to an inputstream and then the EXIF tags are examined. The examination is necessary because it checks if the concerned tags already have text content as well as the value stored in them. None of the digital images used in this work contained any meaning data. So basically the JPEG file is processed as follows:

1. Get all the metadata properties that are currently in the EXIF directory.
2. Create the author, title, keywords, comment tags with the data from the text file.
3. Write the new tags into the EXIF directory and the root directory of the jpeg metadata.

Once the content of the EXIF directory are modified, the file is saved. The results of these steps are discussed in the next section of the paper

3. RESULTS

Available descriptive metadata were automatically embedded into the EXIF section of digital image header of selected natural JPEG images from an image dataset. The resulting metadata which can always be extracted and used for retrieval purposes was made mobile, searchable and non-obstructive. The results of the process can only be viewed when the metadata of the file is extracted and displayed or stored elsewhere, since the metadata is encapsulated within the header section of the image file.

Figure 8 shows the extracted and displayed metadata field for an input file “birthday pix 076.jpg”. This Figure shows a snapshot of some of the EXIF properties of “birthday pix 076.jpeg” before it was modified and updated. It can be seen from the snapshot that the following fields XPAuthor, XPTitle, XPComment and XPKeywords have no values in them. The output shows “Not found” for these fields. The only field with a value is the XPKeywords field, unfortunately, the values are meaningless and incomprehensible.

```
Output - Metadata2 (run)
run:
file: C:\Users\Nancy\Documents\Research Work\PhD codes\images for tagging\birthday pixs 076.JPG
XResolution: 180
Date Time: '2012:09:17 15:21:26'
Date Time Original: '2012:09:17 15:21:26'
Date Time Original: '2012:09:17 15:21:26'
ISO: 800
Shutter Speed Value: 118/32 (3.688)
Aperture Value: 92/32 (2.875)
Brightness Value: Not Found.
GPS Latitude Ref: Not Found.
GPS Latitude: 48, 49, 48, 48
GPS Longitude Ref: Not Found.
GPS Longitude: Not Found.
XPAuthor: Not Found.
XPComment: Not Found.
XPKeywords: 98, 0, 105, 0, 114, 0, 116, 0, 104, 0, 100, 0, 97, 0, 121, 0, 32, 0, 112, 0, 105, 0, 120
XPTitle: Not Found.
```

Fig. 8. EXIF properties before modification

After modification, these fields were updated with values taken from the text file. The result is displayed in Figure 9. Figure 9 shows the result of updating some of the EXIF properties of “birthday pix 076.jpeg”. The screenshot shows the enriched metadata properties of the file with the following fields updated with descriptive metadata: XPAuthor, XPTitle, XPComment and XPKeywords. The original image was enriched with the descriptive metadata making it possible to extract and search the fields while ensuring that the actual visual contents of the image have not been obstructed by the ‘tags’.

Output - Metadata2 (run)

```
run:
file: C:\Users\Nancy\Documents\Research Work\PhD codes\images for tagging\birthday pixs 076_2.JPG
XResolution: 180
Date Time: '2012:09:17 15:21:26'
Date Time Original: '2012:09:17 15:21:26'
Date Time Original: '2012:09:17 15:21:26'
ISO: 800
Shutter Speed Value: 118/32 (3.688)
Aperture Value: 92/32 (2.875)
Brightness Value: Not Found.
GPS Latitude Ref: Not Found.
GPS Latitude: 48, 49, 48, 48
GPS Longitude Ref: Not Found.
GPS Longitude: Not Found.
XPAuthor: 'Robert and Woods'
XPComment: 'Identified and tagged object'
XPKeywords: 'Cup;green_cup'
XPTitle: 'Family'
```

Fig. 9. EXIF properties after the modification

4. DISCUSSIONS

The embedded metadata are non-obstructive in the sense that they do not obstruct any portion of the image itself as against the result displayed in Figure 5. The metadata is also mobile, because it is embedded within the header section of the image and therefore, moves with the image. This is better that the approach where the annotation or tag is external to the image and may be lost if that image is removed from it source.

Since the technology and communication of today, centres on multimedia capabilities of mobile phones and handheld devices driven by the Internet and social network, which has increased the rate with which digital images are acquired and stored by both organisations and individuals. Consequently businesses and persons have created huge collections of digital images that have become cumbersome to explicitly identify and retrieve due to several reasons. Some of which are change in identity of an image once the image is accessed and saved away from its original source, manipulations and modifying of images by other individual apart from the owners and sometimes the inability to correctly qualify images. These can make subsequent retrieval of the image demanding. Identification, qualification and subsequent retrieval of digital images have been generally achieved with processes such edge detection, manual and visual identification of digital images by humans as well as manual annotation of digital images. These processes are either cumbersome, time consuming.

By automatically embedding descriptive data called metadata in the Exif portion within the jpeg image header, will make such metadata mobile and searchable. Mobility in the sense that even if the image left its source, it moved with its descriptive data which can be easily identified and read for image retrieval purposes. The embedded metadata was un-obstructive and mobile. This means that even if such images left their original source, they moved with their descriptive metadata. This makes the images easier and faster to retrieve and reduces human error.

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