NFC-Based Image Annotation

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Abstract. Image retrieval most commonly uses text-based search, which requires the availability of image annotations. As digital photos are growing rapidly in number, making manual image annotation impractical, the need for automatic image annotation is evident. While current approaches to automatic image annotation is based on analysis and interpretation of visual image features and/or image metadata, we present a novel approach to image annotation based on the use of NFC technology. Through a simple touch of an NFC tag, an image capture application obtains accurate annotation information that is automatically added to images. The paper describes how images are associated to the correct NFC tag, enabling a single tag scan to facilitate automatic annotation of multiple images. We also describe how NFC-provided annotations can be used for obtaining more image relevant information from sources on the Internet.

Keywords: Image annotation, NFC-based image annotation, NFC technology, Collecting image information.

1 Introduction

As an enormous amount of digital photos are currently available, an important challenge is to manage them so that relevant photos can be found and displayed in an effective manner. Text-based image retrieval (TBIR) is today the most common technique for searching images [1, 2]. TBIR allows users to formulate high-level semantic queries, and are often more accurate and efficient in identifying relevant images compared to content-based image retrieval (CBIR) [3–5]. However, the technique requires the availability of image annotations (such as tags, description and/or title) that reflect image content. As manual annotation of images is time consuming and impractical due to the huge amount of images [5, 6], solutions for automatic annotation of images are needed. Additionally, automatic annotation may also be needed since people do not necessarily know or remember the names of all depicted objects (for instance attractions visited during a holiday).

Automatic image annotation has received a lot of attention during the last years. Many tools for automatic and semi-automatic annotation use content-based image retrieval (CBIR) techniques for linking visual features to keywords [5, 7]. However, despite the achievements in CBIR, bridging the semantic gap

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between low-level visual features and high-level semantic concepts is still a challenging task [3, 8]. In addition, CBIR techniques often suffer from low efficiency and scalability caused by the high dimensionality of visual features [5, 9]. Some resent approaches to automatic image annotation combine content analysis techniques with the use of image metadata, such as GPS position, to locate related images on the Web from which annotations can be collected [10–15].

Common to all automatic image annotation techniques, is that annotations are inferred and assigned to an image after analysis of image features and/or image metadata, and based on a probability that the selected annotations are relevant for the image. The accuracy of the techniques vary, and depend on many aspects, for instance the choice of annotation model and how well it can bridge the semantic gap between image features/metadata and semantic image content.

To enable accurate image annotation, we present a novel approach where NFC technology on an Android based cellular phone is used to provide a photo capturing application that automatically adds NFC-provided information as annotation to images. When taking images of an attraction or event, the user obtains image annotations by simply scanning an NFC tag related to the attraction/event. The NFC tag provides a URI that the application uses to contact a server and download textual information that is automatically added as metadata to the images.

This paper describes the photo capture application NfcAnnotate that annotate pictures with data from NFC tags. An important part of this application, is our solution to the challenging task of associating images to the correct NFC tag. We also describe an application for registering image annotations in a supporting backend server, and we describe how NFC-provided annotations can be used for obtaining more image relevant information from sources on the Internet.

2 Background

2.1 Automatic Image Annotation

Automatic and semi-automatic image annotation is the focus in a number of publications, which describe different approaches to selecting textual terms from semantically labeled image samples or previously annotated images. Much work has been done on annotating based on content analysis of images, where machine learning techniques are used to develop image annotation systems that map low-level visual features of an image to high-level concepts [5, 7, 16, 17].

A number of systems annotate a query image by selecting terms from related images gathered from online image collections, such as Flickr[1] and Panoramio[2], based on a combination of geographic position and visual similarity [10–15]. The general technique is to first collect a set of images within a certain radius of the query image, narrow down the set by using visual similarity techniques, and finally collect terms from the remaining images.

[1] `http://www.flickr.com/`
[2] `http://www.panoramio.com/`

Expansion of user provided image keywords is described in the work of [4, 18–22]. Existing keyword(s) of the image to be annotated, are used in a search that retrieves related images from which candidate terms can be collected. New terms, recommended as expansions, are selected based on visual similarity between images and/or co-occurrence analysis of tags.

Automatic image tagging in mobile phone applications is described in [23–25]. The work in [23, 24] suggest location tags to photos based on information such as location, previously used tags, tags from social contacts and temporal information, while [25] focuses on identifying people in an image by using sensors that detect for instance movement and direction.

The work of [26] describes an early attempt to an NFC-based tourist application and gives a high-level description of a ticketing and photo annotation system. The paper is of a general nature, and does not convey how images are associated with the NFC provided information.

While most of the referred work infer image annotation based on analysis of image visual features and/or image metadata, our approach offers accurate image annotation through the use NFC technology. We provide an new approach in automatic image annotation, where the upcoming NFC technology for tagging our environment, conveniently can be used to add exact annotations to images, and thus avoid interpretations and possible selection of wrongful annotations. In our work we focus on the important issue of how images and NFC-provided annotations are associated. A detailed description of a prototype for NFC-based image annotation is also given.

2.2 NFC and Information Services

NFC Technology. Near field communication (NFC) is a set of short range wireless technologies in family with RFID [27]. It is limited to distances below 10 cm (typically 4cm). This short range is a feature of NFC and not a limitation. The short range can be used to provide context information (presence, selection etc.) and might also be a security feature. NFC provides different bandwidths for communication in the range from 106 kbit/s to 424 kbit/s. NFC communication involves an initiator and a target. The initiator generates an RF field than can power a passive target. Therefore NFC targets do not need a built in power source and can take simple form factors (stickers, key fobs, cards).

NFC tags contain data either custom encoded or using an NFC Forum[3] tag type specification. Data on NFC tags can be typed using MIME types, URI types, or other type specifications. Three NFC operating modes have been defined. In *reader/writer* mode the initiator can read and write data to NFC tags. In *card emulation* mode a card is emulated. This can be a credit card, a key card, tickets or similar. A typical example is a mobile phone emulating a credit card for touch-less payment where the details of this card is stored on a secure element on the phone (e.g. the SIM card). The final operating mode is *peer-to-peer*. In this mode two NFC devices are communicating as peers. A typical example

[3] `http://www.nfc-forum.org/`

is two mobile phones interacting using NFC. In this paper the reader/writer operating mode is used to annotate images.

NFC-Based Information Services. Many information providing applications using the reader/writes NFC mode has been developed [28]. In its most basic usage, data is collected from the NFC tag and displayed on the screen of the mobile device, while in more advanced applications the receiving of information triggers additional processing or delivery of user provided information [28]. Examples of some information providing applications include smart poster applications [29], touch and interact [30], location-based wikis [31] and mobile museum guides [32].

The work of [29] describes an NFC-based solution that helps users finding locations of interest points within a city and navigate to them. Smart Posters are disseminated in the city and provide text and visual information corresponding to the places where they are located. [30] describes an interaction technique that combines mobile phones and public displays. A mesh of NFC tags forms a display, and interaction takes place by touching the display with a phone to read information from a tag. Discussion of a location-based mobil wiki is done in [31], where a touch of an NFC tag should let the user not only open a web page, but also create mobile and local content in the context where they are. A final application example is a mobile guide that uses the interaction with a dynamic NFC-display to let users explore a museum [32].

Current and potential applications of NFC in tourism are reviewed in [33]. These includes, among others, applications like the ones described in [29–32]. Many field trials testing NFC technology, have recently been conducted, and [33] refers to some of the trials where tourist information is provided through NFC technology. Examples are testing done in the city of Nice, at the ski resort Vail (Colorado), at the Museum of London and Google field trials in three cities in the United States.

NFC-based tourist applications are of specific interest in our context, as they demonstrate the interest in a community to use NFC technology to provide people with information about points-of-interest, attractions and events. We believe that a next step in many cases could be to provide information useful for NFC-based tagging of images, as described in this paper.

3 NFC-Based Image Annotation

This chapter presents an NFC-based image annotation application, named Nfc-Annotate, that captures photos and associates them with textual annotations collected through scanning of NFC tags. The application also displays the photos with annotations, and allows the user to change image metadata or simply delete the image.

3.1 NfcAnnotate Architecture

The architecture for NFC-based image tagging, shown in Figure 1, includes two parts, where the lower left part displays the process of registering image annotation

information in a backend system and writing a corresponding URI to the NFC tag. The upper right part displays the activity of scanning NFC tags and taking images. In our system, we assume NFC tags with low storage capacity, where only a URI to the backend system is stored on the tag. All annotations for an image are thus collected from the backend system by following the URI.

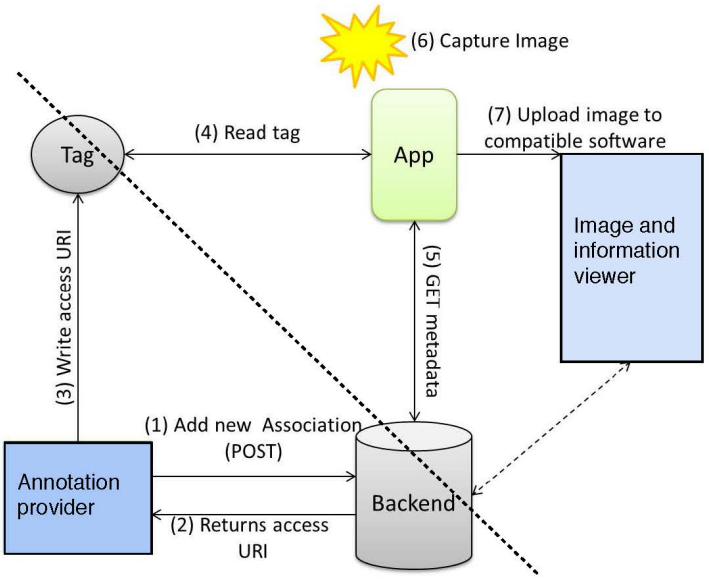


Fig. 1. Architecture of NFC-based image annotation

Registering image annotation information for an attraction or event is first done by filling in a form with the appropriate information and posting it to the backend system. The backend system stores the information and responds with a URI that is subsequently written to an (or a number of) NFC tag(s) that are located at/on the specific attraction or event. The backend system can hold information about a number of attractions and events, each uniquely identified with a URI.

A user with the NfcAnnotate application stored on a mobile device can, before or after taking an image, scan an NFC tag holding information about the captured attraction/event. The URI on the NFC tag is used for collecting image annotation information from the backend system, and the information is stored as metadata on the image. If a connection to the backend system is not available, NfcAnnotate stores the URI on the image, making it possible to later download the annotations.

Images can also be uploaded to some compatible computer software (via wifi or Bluetooth), where they can be displayed and managed. For this, we are currently using the InfoAlbum system [34], that displays images together with information relevant to the image, such as annotations, Wikipedia articles, Web pages,

and other images of the same attraction. If the URI is available on the image, InfoAlbum communicates with the backend system to obtain image annotations. InfoAlbum is additionally capable of collecting more image relevant information from various sources in the Internet based on the NFC-provided annotations and other image metadata.

3.2 Associating Tags and Images

To enable NFC-based image annotation, an NFC tag must be scanned and information about the attraction/event, subsequently collected from the backend system. A main challenge, however, is to associate an image with the correct tag.

A number of images can be taken of the same attraction or event, and we do not want to scan the tag each time an image is taken. One scan and multiple tag-image associations must be possible. Also, the tag might be scanned before or after image capture, and there might be a significant time gap between scan and capture. Finally, as there will never be an NFC tag for every image motif, some images will not have an image-tag association.

Formally, we describe the image-tag associations as $\{o, t\}$, where o is an image and t is an NFC tag. If an image o is not part of an image-tag association, this is denoted $\{o, -\}$. The URI on tag t is used to obtain a set of terms, $\{term_1, \ldots, term_n\}$, that are subsequently stored as annotations on o.

An image group $O = \{o_1, \ldots, o_n\}$ represents a group of images that are related to the same attraction/event, and can be associated as a group to an NFC tag, i.e. $\{O, t\}$. This means that all images in O will be given the same set of annotation terms.

An image group is in our system a set of continuously captured images. By scanning an NFC tag t, an image group is (in most cases) started, and every image taken until the group is ended, are associated with tag t. The group is ended (and a new started) when a new tag is scanned. The application also gives the user the option to manually end the group.

To allow for situations where images of an attraction are taken before the tag is scanned, and for taking images that are not associated with any tags, we use a combination of NFC tag scanning and user participation to identify image groups. In Figure 2a we see the image management interface of NfcAnnotate, with buttons (i.e. *Change* and *Stop*) for starting and ending groups.

Table 1 shows the start/end group activities, and the resulting image grouping and associations. In addition to the images-tag association $\{O, t\}$, we use the *Undefined association* $\{O, -\}$ and the *None association* $\{O, N\}$. The Undefined association is used when the photographer wants to add NFC-based annotations to the images, but a tag has not yet been scanned, while the None association is used when an image group has ended without a tag scan.

From Table 1 we see that if an image group O is started with a scan of tag t, the association $\{O, t\}$ is immediately stored. This image group remains active, meaning that new images are added to the group, until a new tag is scanned or the Change or Stop button is pushed. Scanning a tag t having an active group

Table 1. Image group - tag association when starting and ending image groups

Activity	Situation	Image grouping	Association
Touch tag t	no active group	start group O	$\{O, t\}$
	active group, $\{O_1, t'\}$	end group O_1,start group O_2	$\{O_1, t'\}$ $\{O_2, t\}$
	active group, $\{O, -\}$	continue group O_1	$\{O, t\}$
Push Change	no active group	start group O	$\{O, -\}$
	active group, $\{O_1, t'\}$	end group O_1,start group O_2	$\{O_1, t'\}$ $\{O_2, -\}$
	active group, $\{O, -\}$	end group O_1,start group O_2	$\{O_1, N\}$ $\{O_2, -\}$
Push Stop	no active group	nothing happens	$-$
	active group, $\{O, t\}$	end group O	$\{O, t\}$
	active group, $\{O, -\}$	end group O	$\{O, N\}$

O_1 associated with tag t', i.e. $\{O_1, t'\}$, results in the end of group O_1 and start of group O_2 with association $\{O_2, t\}$.

Pushing the Change button, ends an active group and starts a new group with an undefined association, i.e. $\{O, -\}$. A following tag scan, does not start a new group, but will rather identify the association $\{O, t\}$ and continue the current group. If the Change button is pushed once again without a scan of a tag, the association is changed to None, $\{O, N\}$. The relation between images in O are kept, as they are grouped and belonging to the same, undefined topic. The user can later assign annotations to the set of images.

The *Stop* button ends a group without starting a new one. The following images will not be grouped and there will be no association to any tag. This is useful when the next image(s) will not be related to an NFC tagged attraction/event.

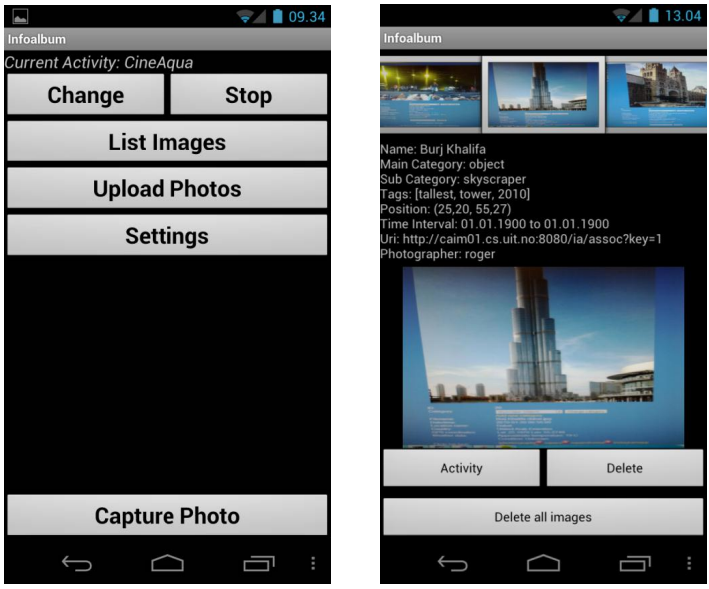
3.3 Managing and Displaying Images on the Phone

The NfcAnnotate application allows users to capture, manage and display images taken when using the application. Figure 2 shows two screen shots from NfcAnnotate, one presenting the interface for images management and the second giving an example of how an image is displayed on the mobile device.

In Figure 2a we see, in addition to the Change and Stop button for grouping images, that the user can list previously captured images, upload images to compatible software on a computer, and access settings for the application. The last button *capture photo* is used for activating the camera and taking photos.

Figure 2b shows how an image with associated information is displayed. At the top of the screen, available images are presented as a list, where an image can be chosen for display. Below, one of the images is displayed, together with image annotations and other metadata, such as name of attraction, textual terms, GPS coordinates and time of capture.

The application stores annotation information for each NFC tag that is scanned. This allows users to manually associate image groups and tags. An NFC tag is often placed on or near the attraction or event for which information is provided. However, one also finds NFC tags on posters (located far away from



(a) Image management (b) Displaying an image

Fig. 2. NfcAnnotate interfaces on mobile device

the attraction) and even in brochures (that can be read long before exploring the attractions). The user can in these cases scan a number of tags, that are subsequently stored on the device. When later taking images of an attraction, the user can group images using the NfcAnnotate interface and assign the proper tags to the group.

NfcAnnotate uses NFC tags that are linked to a remote backend system holding annotation information. It has been pointed out that contacting to a remote server may be expensive, especially for foreign users, because of high data roaming charges in many countries [33]. In our application we avoid such costs by storing the URI on the image and collecting annotations when connected to wifi. Also when NFC tags with more storage capacity are used, the annotation information can be stored directly on the tag, making access to a backend system unnecessary.

3.4 NFC Tag Information Registering

To register annotation information on NFC tags, we have implemented a client application with a user interface as shown in Figure 3. In the name field, the user will typically give the exact name of the attraction or event, and then provide three descriptive terms. It is also possible to add GPS latitude and longitude values and a start/stop date. A GPS position gives the exact location of the attraction/event, and can later be used to retrieve other context related material such as location names or images taken by other persons in the same

area. A start/stop date is typically used for events that take place within a time-interval, and can be used to focus a search for more information about the event. Such additional information is in our environment provided by the InfoAlbum software that is described in Section 4.

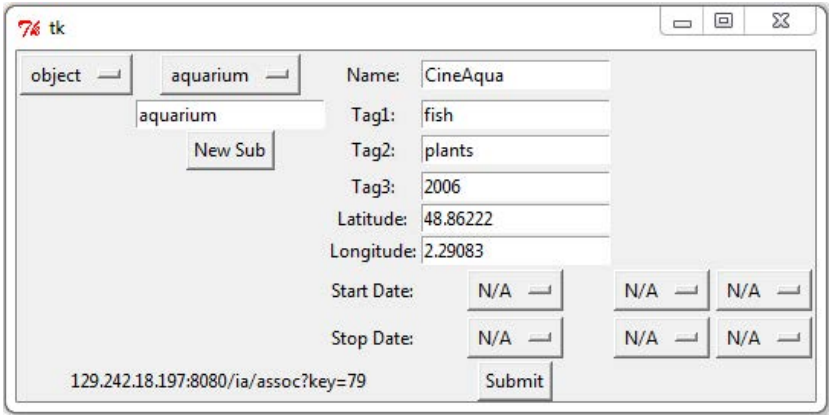


Fig. 3. Specification of annotations for an attraction

In addition to name and terms, the system allows for specifying the general nature of the attraction/event. This means that the user identifies if the annotation information describes an object (i.e. some attraction/point-of-interest) or an event. The user also gives a general description of the attraction/event by categorizing it, for example as a "church", "bridge", "tower", "concert" or "festival". The example in Figure 3 shows that the attraction named CineAqua is described as an "aquarium" of type "object".

All information provided by the user is uploaded to the backend system, and a URI is returned. Next, the URI is written to NFC tag(s) and made available to the public user.

4 Image Information Album as Supporting Application

The NfcAnnotate application allows users to upload images to a supporting application where images and image related information can be displayed on a computer. For this purpose, we have used the InfoAlbum system [34], which presents images together with information about image content and the location of image capture. This information includes attraction/event name, terms, location names, temperature and weather condition at image capture time, placement on map, geographically nearby images, Wikipedia articles, and web pages. Some of the information, such as attraction/event name and terms, are provided by the NfcAnnotate application. The other information is automatically collected by InfoAlbum, from available sources on the Internet, based on image metadata.

The accurate image annotation provided by NfcAnnotate, including name of the attraction/event and GPS coordinates, is very useful metadata that in InfoAlbum is used for expanding with more information. The information automatically collected by InfoAlbum is listed in table 2, where we also see information sources and the metadata needed for obtaining the information.

Table 2. Image relevant information collected by InfoAlbum

Collected information	**Source**	**Metadata**
Location names	Flickr	GPS coordinates
Nearby images	Flickr, Panoramio	GPS coordinates
Position on map	Google	GPS coordinates
Weather information	Weather Underground	GPS coordinates, date/time
Wikipedia articles	Wikipedia	Attraction name, Location name
Geo-tagged Wikipedia articles	Wikipedia via GeoNames	GPS coordinates, Attraction name
Web pages	Google	Attraction name, Location name, date/time

Given an image of interest *o*, *location names* (i.e. country, county and locality), *position on map* and *nearby images* taken by others are all collected based on the GPS coordinates of *o*, while *weather information* is obtained from Weather Underground[4], by first finding the closest weather station based on latitude and longitude values, and secondly by finding historic information based on the date of image capture and ID of the weather station.

Wikipedia articles are obtained through search on Wikipedia[5] directly, based on attraction and location names, and through searching geo-tagged articles kept by Geonames[6]. GPS coordinates and a radius of interest are input to Geonames, which returns references to Wikipedia articles. Attraction name is then used to identify (if available) the article describing the attraction depicted in the image. Finally, *Web pages* are collected through a Google search, using attraction name and location name as search query. For events images, a time period of interest is additionally used when searching information about the event.

In [34] we reported on testing of InfoAlbum and its ability to collect relevant web pages based on image metadata. In that previous work, exact attraction/event name were not available, but the system rather based the information search on a user provided category keyword, similar to the category information in NfcAnnotator. With the use of NfcAnnotate, attraction/event name is now easily available, and is, not surprisingly, very useful as basis for collecting more relevant information.

In a new test, we compared InfoAlbum results using NfcAnnotate annotations as basis for collecting web pages, to the previous testing where only category

[4] `http://www.wunderground.com/`
[5] `http://www.wikipedia.org`
[6] `http://www.geonames.org/`

information were available. The results show that the average precision score increased from 0.43 to 0.91 with the use of NFC-based annotations. The test was based on 50 attraction images, where InfoAlbum executed, for each image, a textual search in Google, filtered the results against a filter list and presented the 20 top ranked web pages to the user. A filtering technique was implemented to ensure that repeatedly occurring, irrelevant web pages were not presented to the user.

5 Discussion

Our approach to NFC-based image annotation combines NFC-tag scanning with the possibility for user participation to determine image-tag associations. This approach brings both opportunities and limitation.

The approach has the advantage of allowing the user to group images as the user finds best. The ability to group images is useful also when NFC-tagging is not available. In such cases, the user can start and end the image group using the NfcAnnotate application and in one operation attach custom tags to all images in a group.

The grouping of successively captured images may well result in a number of groups that associates to the same tag. This may happen if the user switches between topics, for instance while visiting an attraction, described through some tag t, first takes some photos of the attraction, then some images of family members and/or landscape, and continue with more images of the attraction. To automatically associate tag t with both groups, the tag must be scanned twice. Alternatively, the user can manually associate one of the groups with t, since the tag is scanned and stored by the NfcAnnotate application.

On the other hand, the option for user interaction may complicate the process of taking images, in that the user may need to actively start and/or end image grouping. The user must also be aware of how images are grouped, and that for instance a change of topic may require a manual end of group.

Before implementing our current version of NfcAnnotate, we considered using automatic grouping of images based on closeness in location and time between images, and closeness between images and NFC tag. We found, however, that it may be difficult to determine threshold values for both time and distance, since in many cases multiple attractions are located very close and that two images of different attraction may consequently be close both in time and space.

Our approach could also be supplemented by content analysis of images, where similar images can be grouped together [3]. However, in our case we expect visually dissimilar images to be grouped together, as an attraction can be photographed from different angles, outside and inside, and that photos of different artifacts can be part of the group. This makes it very challenging to rely on content-based analysis of images, and this possibility was consequently also discarded for the current implementation of NfcAnnotate.

Based on these considerations, we decided for an approach where users have the possibility to effect the grouping of images, and also provide their own tags if

NFC-tagging is not available. This to avoid the uncertainty introduced by more sophisticated techniques, and the possibility of incorrect image grouping.

6 Conclusion

We have in this paper described a novel method for automatic image annotation using NFC technology. When taking a photo with an Android based mobil device, the NfcAnnotate application enables image annotation by simply letting the user scan an NFC tag that holds information about the attraction or event depicted in the image. The paper described how images of the same attraction/event are grouped and associated with the proper NFC tags, so that a single tag scan can facilitate automatic annotation of multiple images.

This method provides the user with accurate image annotations (such as attraction or event name and GPS coordinates), and is not relying on interpretations or mappings from visual features or image metadata. Annotation information is registered once by an information provider (such as a travel agency or attraction owner), stored in a backend system, and can be fetched by mobile devices running the NfcAnnotate application, using the URI information read from the NFC tag.

This paper also described a supporting application, named infoAlbum, where the annotated images can be displayed and where NFC-provided annotations are used as a basis for collecting more relevant information from sources on the Internet. Additional information provided by InfoAlbum includes Wikipedia articles, Web pages, location names, weather information, placement on map and other images of the same attraction/event. Testing showed that the accurate NFC-provided annotations (such as name of attraction/event and GPS coordinates) represents a very good basis for collecting additional relevant information to the images.

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