Media Content Metadata and Mobile Picture Sharing

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Abstract. This paper describes two systems for picture taking with mobile phone cameras. The first system, *MMM*, is a platform for generating semantically rich metadata for mobile pictures at the time of image capture. The second system, *MobShare*, is a mobile picture sharing and discussing system that takes advantage of the temporal and social information in the camera phone. The paper also discusses combining the two approaches in designing a mobile picture sharing system that both generates and takes advantage of semantically rich metadata.

1 Introduction

Amount of personal digital media is increasing. More and more people have digital media recording devices for capturing video, sound, and images. In addition, people receive, watch, and store digital media recorded by other people almost on a daily basis. This increase brings with it the problem of media management: how to manage, search, browse, and share the tens of thousands of pieces of digital media we create and receive. The management of personal media must be automated, and one solution is to have information about the media's content in a computer-readable form, that is, media content metadata describing, for example, who are the people in the picture, where was it taken, and what event it is part of. Many consumer photo management software as well as academic systems already take advantage of content metadata (see, *e.g.*, [1, 6, 7, 10, 16]).

However, achieving the media content metadata is not simple. Automatic extraction of the metadata from digital media produces relatively low-level information which is not necessarily the kind of semantic information people are looking for. On the other hand, people themselves can easily produce the semantic content information for personal media, but going through thousands of pieces of media and annotating them with metadata is much too tedious and time-consuming.

Mobile phones with integrated cameras provide a solution to this problem. They are ubiquitous devices that have access to contextual and personal information at the time of media capture (*e.g.*, location, time, calendar, and address book), have an inherent network connectivity (*e.g.*, GSM/GPRS, Bluetooth), and have an open programming interfaces (*e.g.*, J2ME, Symbian, BREW). These key features make it

possible to combine the automatic extraction of metadata with the human ability to easily identify semantic information, therefore, making camera phones a promising content metadata creation and annotation platform.

A good example where the special characteristics of mobile phones have been taken advantage of are the emerging picture publishing and sharing systems (see, *e.g.*, [2, 5, 9, 11, 14, 15]). These "photo-blogging" or "moblogging" systems enable people to share and publish their images directly from the mobile phone to a web page. Many of these systems have also a discussion functionality for other people to comment the images. Also, some of the systems have organizing features that allow the user to categorize the pictures into albums rather than having a single web page where the images are posted. This immediacy in publishing and sharing pictures is something that has not been possible with traditional digital cameras which always require an intermediary PC for posting the pictures on the Internet or sharing by email. These new mobile picture systems are an example of the new ways people will create and share more media, hence contributing to the media management problem mentioned above.

This paper looks into the creation of media content metadata using mobile phones. We describe two mobile picture systems we have created, *MMM* and *MobShare*, and using them as examples discuss how metadata creation could benefit from mobile picture sharing, and vice versa.

In Section 2, we describe our previous work in mobile media content metadata [12], where a metadata creation system *MMM* was designed, implemented, and tested. The system was designed primarily for annotating mobile images at the time of capture, and did not focus on publishing, sharing, and communicating using mobile pictures. Section 3 describes our mobile image sharing and communication system *MobShare* [13] where we focused on immediate and controlled sharing of mobile pictures and enabling users to discuss, compare, and combine their own and other people's pictures. Although *MobShare* uses contextual and social metadata, in contrast to *MMM* it was not designed primarily for creating descriptive metadata. In Section 4 we discuss our future work in combining these two approaches so that metadata creation can benefit from the social activities in mobile picture sharing, and the mobile picture and sharing can take advantage of the media content metadata created at the time of capture. Section 5 concludes this paper.

2 *MMM*: Media Metadata Creation with Mobile Phones

As mentioned above, media content metadata facilitates the management of digital media. Having information about media content, such as *who* is in a picture, *where* it was taken, *what* is the picture about, and *when* it was taken, enables effective ways of browsing, managing, and searching the media. For example, to find pictures taken at a certain location, at a given time, and with specific people in the pictures.

However, one of the main issues with content metadata is the creation of it. As mentioned in the introduction, automatic extraction produces mainly low-level information (*e.g.*, color histograms, shape recognition) rather than the high-level, more semantic information that people would like to have (*e.g.*, who, where, when,

and what). On the other hand, annotating the semantically rich information that people can easily provide is too time-consuming.

In the *MMM* system [12] we combined both automatic processing and user annotation to get the best of both approaches. Immediately after capture a client program on the mobile phone gathered contextual information and interacted with the user. Then the captured picture and gathered information were sent to a remote server for further processing. After the processing the generated information about the content was sent back to the user for verification. See below for a more detailed description of the metadata creation process. Also, in this section we describe the *MMM* system by a use case, give a brief system description and evaluation.

2.1 Use Scenario: The Campanile

This use scenario describes how the designed metadata creation process should ideally work. A more detailed description of what was implemented is given below. The scenario is from a user's point of view and refers to Figure 1.

Stephen is visiting the UC Berkeley campus in California, and takes a picture of the Campanile bell tower, which is a very popular object of photography in Berkeley. He points the camera phone at the Campanile, and pushes the capture button (part a *in Figure 1). The image on the screen is frozen, and the phone asks him if the image subject is a Person, Location, Object, Activity or something else (part* b *in Figure 1). Then he uploads the image to a server (part* c *in Figure 1), and after the upload a new screen is open where the system presents Stephen with guesses about the information regarding the picture (part* d *in Figure 1). From the screen he can see that the system has already guessed correctly that the image is about the Campanile and the setting of the picture is Outdoors. He verifies this information by pressing OK, and receives a new set of guesses. This dialog between Stephen and the remote server via the user interface continues until all guesses are answered.*

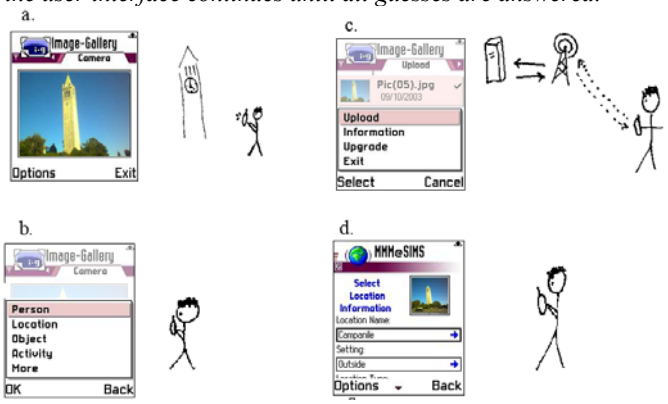

Fig 1. The picture-taking and annotation process. **a.** The user takes the picture. **b.** The user selects the main subject of the picture from the phone's UI. **c.** The user uploads the picture to the remote server. **d.** The server responds with guesses about the metadata.

In the end, after the Stephen has verified the guesses to be right and corrected the wrong ones, the system can add more information based on the accurate information: the location of the picture is the UC Berkeley campus, City of Berkeley, County of Alameda, State of California, U.S.A.; the image was taken on Thursday, October 9th, 2003, 15:34 PST; the object of the picture is The Campanile also known as the Sather Tower, a stone bell tower, completed in 1914, height 94 meters; and so on. By few pushes of a button Stephen has annotated the image with almost twenty pieces of metadata.

2.2 Metadata Creation Process

To implement the scenario described above we designed a metadata creation process consisting of four parts (see, Figure 2). The first part of the process after the image capture is the gathering of contextual metadata. As the image is captured the phone itself has access to contextual information such as location (network cellID), time and date, and username (*i.e.*, the user's phone number). This information is gathered and associated with the captured image. In addition, the user is prompted for the main subject of the picture (*i.e.*, Person, Location, Object, Activity, or More). The main subject is valuable information for the server-side processing because if the main subject is a person, then it can make some selections about the information extraction algorithms to use. The gathered contextual data and the main subject selected by the user is sent to the remote server with the actual image.

On the server the received picture and metadata are processed to generate more metadata. The process looks into previously stored pictures and metadata to find similarities. For example, if the main subject is a person and the user often has the same people in the picture then the probability of those people being in the new picture is higher. Or in the case of the Campanile, many people take a picture of the same object in the same location. The process also makes simple inferences like the day of the week from the given date.

An important part of the automatic metadata generation is the sharing of all pictures and metadata within all users of the system. In other words, the sharing makes it possible to leverage the spatial, temporal, and social similarities in people's pictures and the associated metadata. The example of a popular tourist attraction like the Campanile shows that although people have no social connections (*i.e.*, they do not know each other) they have similarities in the location and object of their photography. This way the metadata inserted by someone else can be re-used by everyone else [3].

The outcome of the metadata and media similarity processing by sharing and re-using is a set of guesses. Some of the processed guesses have a hundred percent probability of being correct (*e.g.*, day of the week, or region of a given cellID) but some other guesses the processing can not be sure about. The guesses which the server-side processing is not sure of are sent back to the user for verification. This way the automatic processing on the server is combined with user interaction.

The advantage of user verification is that for a person it is easy to identify semantic information which would be difficult to computationally infer. To make the user verification more usable the list of guesses is displayed to the user as a drop-down list with the most probably choice first. For example, the automatic image processing might not be sure if the picture is about the Campanile tower or an empty bottle that happens to be in the same location, but for a person the answer is obvious.

The information verified by the user is then sent back to the server for further processing. Now the server can use other algorithms or make better guesses because the user has provided it with more accurate semantic information. This loop can go on as long as the server-side processing generates more guesses or the user decides to terminate the process.

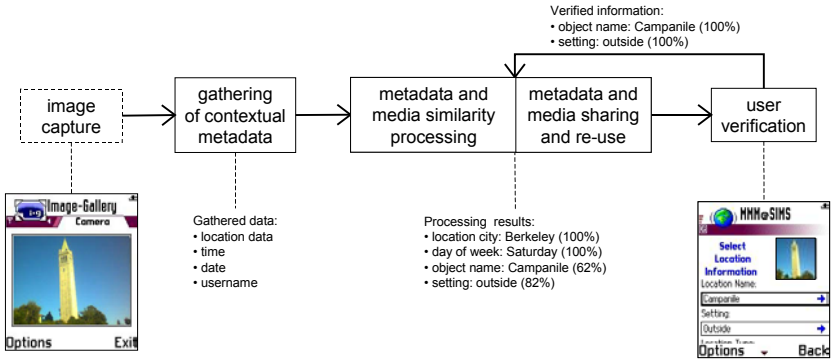

Fig 2. The metadata creation process and the Campanile scenario as an example.

2.3 System Description

The metadata creation process described above was implemented in a client-server model where the clients were Nokia 3650 camera phones and the remote server was a web server. The network used was the local GPRS.

The image capturing, gathering of contextual metadata, user interaction for the main subject, and the image and metadata upload were implemented in a dedicated Symbian C++ application for Series 60 phones. The client application named *Image-Gallery* was implemented by Futurice[1]. The server implementation had an Apache HTTP server and Apache Tomcat as the Java servlet container. The user verification was implemented so that the server created XHTML pages that were requested by the phone's built-in XHTML browser. The pictures and associated metadata were stored in an object-oriented Ozone 1.1 database. See Figure 3 for the main components of the implemented system.

[1] http://www.futurice.fi

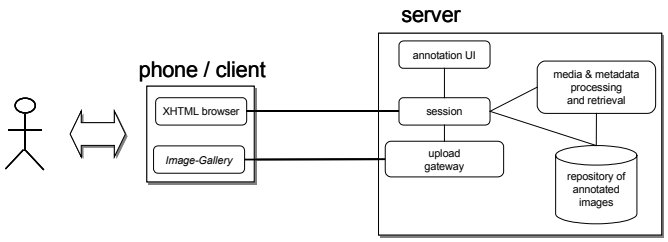

Fig 3. The main components of the *MMM* system.

2.4 Evaluation

The *MMM* system was evaluated in a four month trial by 40 users consisting of students and researchers at UC Berkeley, USA (see [12] and [17] for further information about the tests and evaluation). In addition, there was a usability study made with five users and a focus group evaluation with eight users. The main findings were:

- The client-server interaction over the limited GPRS bandwidth was too slow.
- The phone's limited keyboard and display size caused usability problems.
- People's vocabularies describing the picture contents were divergent.
- Browsing the annotated pictures motivated users to do more annotations.

Overall, the *MMM* user test showed that the designed metadata creation process was successful in creating richly annotated pictures, in other words, digital media with semantic metadata. However, the *MMM* system did not focus on people's uses and needs for sharing mobile pictures. It was primarily designed to implement the metadata creation process as a platform for further applications to use. In the following section we describe the *MobShare* system which was built primarily to fulfill user needs and requirements for sharing and communicating with mobile pictures.

3 *MobShare*: Sharing and Discussing Mobile Pictures

New picture publishing systems are emerging which take advantage of the special characteristics of mobile camera phones. Some of these systems are very similar to weblogs or "blogs" (see, *e.g.*, [11, 14, 15]), where people publish their writings and in this case mobile pictures for everyone to read and comment. The mobile pictures can be published directly from the phone to the Internet, and this is often called "photo blogging" or "moblogging". Other similar systems have more organization features and often are labeled as "web albums" (see, *e.g.*, [2, 5, 9]). These systems resemble more the personal picture management software by having editing and publishing functionality as well as the possibility to limit the access to the pictures by passwords.

The novelty and often the attraction of these mobile picture sharing and publishing systems is the possibility to share or publish the image to the Internet directly from the mobile phone. This immediacy makes it possible, for example, to follow the travels of a friend as the trip progresses rather than wait for her to get home and upload the pictures to the Internet after the trip.

In this section we describe the *MobShare* mobile picture sharing system that was built in Spring 2004 [13]. The system was designed for people to immediately share mobile images with their circle of acquaintances. The main contributions of *MobShare* to "photo blogging" and web album systems were:

- Having organization of pictures into folders on a web album as a part of the sharing process.
- The possibility to fully control with whom the pictures are shared by leveraging the phone's address book.
- Having discussions as an important part of the web album as the pictures themselves.
- Enabling the comparison and combination of pictures taken by the user herself and by other people who have shared the pictures with the user.

In the following subsections we first give a use scenario of the system, then we describe the sharing and viewing features of the system, and in the end we provide an evaluation.

3.1 Use Scenario

The use scenario is divided into two parts. The first part describes the capturing of images and sharing them from the phone. The second part describes the viewing and discussing of the shared images.

Chris is traveling to a conference in San Jose, California, USA. His friend Markus joins him on the trip, and they both have the MobShare *program on their phone. After taking a few images Chris selects some of them for sharing on the* MobShare *web site (see Figure 4). After selecting the pictures he initiates the posting and creates a new folder on the web site for the pictures. He names the folder "Conference Trip". After this his phone's address book pops up and he selects the people he wants to share the pictures with. He selects his friend Anna, who knows both him and Markus. Then the upload starts. Chris puts the phone back to his pocket.*

Fig 4. . The picture uploading and sharing process where a) the images are selected, b) the uplaod is initiated, c) a new folder created, d) named, e) the people selected, and f) finally the images are uploaded.

Anna receives a text message on her phone stating that Chris has shared some pictures with her. Anna logs into the MobShare *web site with her username and password. After logging in, Anna can see her own folders and the folders other people have shared with her, especially the new folder shared by Chris ("Conference Trip") and the folder previously shared by Markus ("San Jose 2004") (see Figure 5). As the timeline show these folders have pictures that were taken within the same time period, and Anna knows that Chris and Markus are in the same conference, therefore, Anna selects both folders to be viewed in a combined gallery (see Figure 6). She can see from the discussions that both Chris and Markus have already commented on the pictures, and she adds her own comments. "I wonder how do Chris's and Markus's trips differ?", Anna thinks and selects to view the two picture folders separately. Now she can compare the pictures on separate vertical timelines (see Figure 7).*

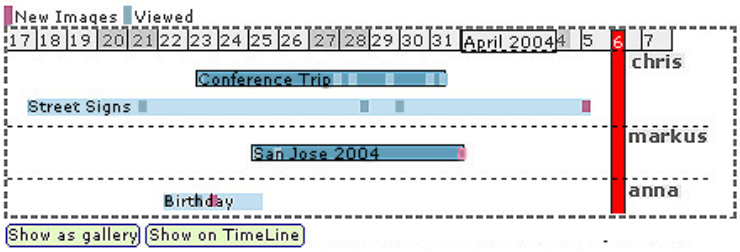

Fig 5. The Horizontal Timeline View of the user's (Anna) own folders and folders shared by others (Chris and Markus). The two selected folders are in darker color.

Fig 6. Gallery view and discussions. The folder-level discussion is on the left above the gallery view. The visibility and visitor information of each folder. The summary of picture-level discussions are on the right.

Fig 7. Vertical timeline view of pictures. Here are the same two selected folders as in Figure 5, but on separate timelines according to the owner of the folder.

3.2 Controlled and Immediate Sharing

The immediacy in sharing mobile pictures will probably add to the overwhelming amount of digital media sent and received. Mobile pictures are often taken *impromptu* and shared more like a message in contrast to traditional paper pictures that are taken with more care and shared after the captured moment has passed. As the amount of digital media increases, organization becomes even more acute. The problem with organizing pictures is that it is often done some time after the picture was taken and it becomes a tedious job where the rewards are not immediate. Also, shared pictures are often not organized at all. For example, pictures sent by email to other people usually remain and get lost in the receivers email inbox.

One of the main features built into *MobShare* was the organization of pictures into folders as a part of the sharing process. In the system all the pictures have to belong to a folder thus forcing the user to categorize them for both herself as well as the receiver of the pictures. The categorization was intentionally built into the sharing process, because the sharing is probably more motivated than any explicit organization task. In *MobShare* also the received pictures are therefore organized into folders.

Another key feature in the sharing process is the use of the phone's address book. People often share pictures with the same people, which are their relatives, colleagues, and friends, in other words a limited number of people. Also, people are somewhat concerned about sharing pictures on the public Internet. Often pictures that are preferred to be kept private are shared using email which enables explicit naming of the receivers. To enable this kind of limited access to shared pictures the *MobShare* system takes advantage of the phone's address book where the phone numbers of the user's circle of acquaintances can be most probably found. Using the phone number makes it possible to identify every user and limit the visibility of the shared pictures to named individuals.

3.3 Browsing, Combining, Comparing, and Discussing

Browsing and viewing pictures is more convenient using a desktop computer with a large screen, a mouse, and a keyboard rather than the small screen and limited input of a mobile phone. Therefore, an important component in visualizing the pictures, in *MobShare* as well as all mobile picture publishing and sharing systems, is the desktop computer and a web browser.

In *MobShare* the main visualization of pictures is the horizontal timeline of folders (see Figure 5). The visualization combines the folder categorization done by the user with the time and date metadata stored in the image file. With these three pieces of information the visualization integrates the familiar folder metaphor with an intuitive calendar timeline.

From the horizontal timeline the user can select the folders (or galleries) to be viewed. The user can view the pictures either as a gallery of thumbnails in

chronological order (see Figure 6 for the "gallery view"), or as a set of vertical timelines (see Figure 7 for the "timeline view"). As mentioned in the use scenario, the user can select one or several folders to be viewed at the same time. In the "gallery view" the pictures in the selected folders are combined into one large gallery regardless of who is the owner of individual pictures. In the "timeline view" the selected folders are put on separate vertical timelines that are synchronized so that the user can compare what pictures were taken at the same time.

The system has also a notification of new pictures. A visual notifier in the horizontal timeline view shows the user if there are pictures inside a folder that she has not viewed (see Figure 5). Also, if a new folder is shared with the user, or the user is a new user, she gets a text message sent to her phone inviting her to view and discuss the pictures.

One of the important parts in sharing pictures is the discussion and social interaction around the pictures. People reminisce events and common histories by looking at pictures, or tell narratives of their own events and happenings to friends and family who did not take part of the event. In *MobShare* we integrated discussion functionality into picture browsing, and promoted it by making the possibility to discuss visible all of the time. Also, we explicitly made it visible to the user who are the people that can see the pictures as well as the discussions; especially in the case of other people's folders where the user can not otherwise be sure who the owner of the folder has shared the pictures with.

3.4 System Description

The *MobShare* system consists of a mobile phone client application and a web application server that is accessed using a regular web browser. See Figure 8 for a system architecture diagram.

The client-side software is a stand-alone Symbian C++ application for Series 60 terminals. The communication between the client program and the web server is built on the HTTP protocol. The underlying data transfer network used in building the system is GSM/GPRS. The client program logs in on the web server using the phone number (MSISDN) as the authentication identifier, and uploads the images and related metadata to the server.

The server used is a J2EE web application that runs on Tomcat servlet container. The uploaded pictures are stored as JPEG image files in the file system. Picture metadata (*i.e.*, time and date of capture and upload, name of picture folder, owner of picture, picture description, and who can view the picture) and user data (*i.e.*, usernames, MSISDNs, and who has viewed what image folders and when) is stored in a relational database. The web user interface is implemented using Dynamic HTML, and it is targeted for the Internet Explorer browser. The server side implementation is based on Struts Web Application Framework and Java Server Pages.

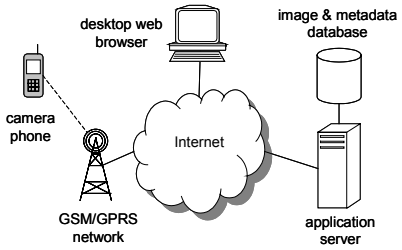

Fig 8. *MobShare* architecture overview.

3.5 Evaluation

As in the previously described *MMM* system, one of the main issues in *MobShare* was the slow transfer speed of pictures from the phone to the server. The limited bandwidth of the GPRS network is a known problem and our measurements showed that the average time for a VGA resolution picture to upload took 19 to 30 seconds depending on the network operator. The problem of slow upload might be solved in future mobile phone networks that have more bandwidth. However, the size of mobile pictures is increasing as well, for example, with a one megapixel camera the size of a mobile image can be 500kb. Therefore, the problem will not solve itself and the slow upload has to be taken care of in the system design. In *MobShare* the upload process can be switched to the background and the phone can be used normally while the pictures are uploaded to the server.

However, the slow network brings about the issue of reliability in the image transfer. If the upload is not reliable, the images have to be loaded several times, and the upload process becomes an overwhelming bottleneck – both as a bad user experience and financially if the user is charged by the uploaded bytes. To counter this problem we implemented a confirmation and acknowledgement into the image transfer to keep the user updated on what pictures are on the server.

Preliminary user studies (users were colleagues, friends, and family of the system designers) have also shown that the discussion feature has a significant role in the use of the system. Therefore, in addition to the notification of new shared pictures, the test users wanted to have a notification of new comments. Also, the explicit list of all the people that can see the pictures seems to have a negative effect on the amount of discussion going on. One user commented that the threshold for commenting became higher once he saw that there were over thirty people who could see his postings, and he knew only few of them. Further user tests are planned for Fall 2004.

4 Future Research: Picture Sharing and Semantic Metadata

Our future research will focus on combining the two approaches described above in designing a mobile picture sharing application that takes advantage of rich semantic

media metadata. In this section we briefly discuss how enabling the *MMM* type semantically rich media objects can facilitate the browsing and searching of mobile pictures, as well as enable more sophisticated and refined uses for shared images. On the other hand, we also discuss how the mobile picture sharing, viewing, and discussions implemented in *MobShare* could facilitate the automatic generation of rich semantic metadata.

4.1 Media Metadata in Sharing Mobile Pictures

The ideal situation of having semantically rich metadata about media would enable more efficient browsing and searching. For example, people could search the shared pictures by location or person. Also, the *MMM* type of faceted hierarchical metadata combined with information who took the pictures, or who has viewed the pictures, could enable interesting statistical information for the users. For example, it would be possible to see who has taken most pictures of some other person, or who is the most viewed person within a group, and so on. In other words, the temporal, spatial, and social similarities manifested by the pictures people take, as discussed in [3], could be visualized and taken advantage of.

However, increasing the amount of information people can browse and search images by creates more challenges on the visualization of the information and the usability of the system. For example, currently the *MobShare* system visualizes pictures by time, the person who shared the picture, and the user defined folder categorization (see Figure 5). Adding another dimension (*e.g.*, the location where the picture was taken) to this visualization would require major changes to the GUI. Having a wide variety of semantic information, like people and their relations to each other, would require a whole new approach to the visualization.

In addition to the possibilities in browsing, searching, and visualization of the shared pictures, semantically rich metadata would enable more sophisticated ways of combining, publishing, and augmenting the mobile pictures. With information like location and time, the system could suggest pictures taken by other people in the same time and place (*e.g.*, a concert or a sports event), or even professional media from the same time and place (*e.g.*, news articles, pictures, and video).

Rich metadata would also enable tools that make, for example, storytelling and publishing easier and more sophisticated. Especially, with information about the semantic and syntactic structures of pictures, it would be possible to automatically produce a professional looking media by having the professional skills (*e.g.*, narrative structures, image semantics) encoded into the automatic production (see, *e.g.*, [4]).

4.2 Sharing Mobile Pictures and Media Metadata

In the current version of the *MobShare* system a lot of information is produced but not necessarily taken advantage of. For example, the logging functionality gathers information about who has viewed what pictures and when, who are the people the folders are shared with, and so on. Also, relatively simple database queries would provide information such as how many people have shared their pictures with any

given user and how many people the user has shared pictures with. In addition to showing connections to people, the system also gathers information about how pictures are linked to other pictures. For example, what pictures are categorized in the same folder, or what picture folders are most often combined or compared. Thirdly, the discussions associated with pictures and folders can provide information about both the people involved in the discussion and the pictures themselves. For example, what picture generated lots of discussion, who were the people discussing, and so on. The Nokia Lifeblog system is a good example of leveraging available information (*e.g.*, text messages) in organizing mobile pictures [8].

In other words, in addition to the contextual information gathered at the time of capture, the sharing process and people's activities in viewing and discussing the pictures generates lots of information. Therefore, the problem is how to refine the information into salient metadata that could be taken advantage of as described in the previous sub-section. As in the *MMM* system, the information can be processed by inference algorithms that generate usable semantic metadata. The results of these algorithms (*i.e.*, the guesses) can be then displayed to the user for verification, as in the *MMM* system. The verification process need not to be too intruding, it can be, for example, a passive display of information that can be easily corrected by any user. However, designing both the inference algorithms and ways of burdening the user with verification and metadata annotation requires an understanding of how and for what purposes people share mobile pictures.

5 Conclusions

This paper described two systems for mobile picture taking. The first system, *MMM*, was a platform for generating semantic metadata for mobile pictures. The metadata creation process implemented by the system combined the contextual information available on the phone at the time of capture, media and metadata processing algorithms that compared and re-used metadata of all pictures in the system, and finally verified the metadata inferences produced by the algorithms by presenting them to the user. The tests showed that the process was successful in generating semantically rich metadata, but the user experience was not optimal, as the interaction was too slow and cumbersome.

The second system described in this paper, *MobShare*, was a mobile picture sharing and discussion system that focused more on usability than generating metadata. However, the system took advantage of available metadata such as time, date, and social information stored into the phone's address book. The preliminary evaluation of the system showed that the discussions functionalities in the system played an important role in the communication between the users.

The final section of the paper discussed future work in combining the two approaches in designing a mobile picture sharing system that takes advantage of semantic metadata. The rich metadata would enable new ways of browsing, searching, and visualizing the pictures, and more sophisticated and advanced ways of creating combined and professional looking multimedia objects from the mobile pictures. On the other hand, the social activities recorded and logged by the mobile

picture sharing system could be used to infer more metadata about the picture contents as well as the social, temporal, and spatial relations of the users.

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