MMM2: Mobile Media Metadata for Media Sharing

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ABSTRACT
As cameraphones become the dominant platform for consumer multimedia capture worldwide, multimedia researchers are faced both with the challenge of how to help users manage the billions of photographs they are collectively producing and the opportunity to leverage cameraphones' ability to automatically capture temporal, spatial, and social contextual metadata to help manage consumer multimedia content. In our Mobile Media Metadata 2 (MMM2) prototype, we apply collaborative filtering techniques to automatically gathered contextual metadata to infer the likely sharing recipients for photos captured on cameraphones. We show that while current cameraphone sharing interfaces are fraught with difficulty, it is possible to use a context-aware approach to make the sharing of cameraphone photos simpler and more satisfying for users. Based on our analysis of the relative contributions of different cameraphone sensors to predicting the likely recipients for photos, we discover for our user population that the temporal context of photo capture proved highly predictive of photo sharing behavior.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation (*e.g.*, HCI)**]: Multimedia Information Systems; H.1.2 [**User/Machine Systems**]: Human Factors; H.3.1 [Information Storage and Retrieval]: Content Analysis and Indexing; H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval; H.5.2 [**Information Interfaces and Presentation (*e.g.*, HCI)**]: User Interfaces; H.5.3 [**Information Interfaces and Presentation (*e.g.*, HCI)**]: Group and Organization Interfaces.

General Terms
Algorithms, Design, Human Factors.

Keywords
Wireless Multimedia, Contextual Metadata, Ubiquitous Computing, Pervasive Computing, Location-Based Services, Collaborative Filtering, Machine Learning, GPS, Bluetooth, Social Networks, Social Software, Digital Image Management

1. INTRODUCTION
While cameraphones are rapidly growing in adoption, the software available to consumers for sharing their cameraphone photos has not kept pace. According to a recent Kodak study, fully two-thirds of cameraphone users have not succeeded in ever getting their photos off their cameraphones. In addition, current cameraphone photo sharing processes require the user to focus on *how* to share the photo—which technological mechanisms and transport protocols need to be used (e.g., "Send via email," "Send via multimedia," "Send via bluetooth")—rather than simply *who* they want to share the photo with. Furthermore, the number of user interface operations (phone button clicks, text keying and contact searching, application switching, etc.) needed to perform the central—and what should be the simple—task of sharing a photo from a cameraphone exceeds most user's patience.

2. CONTEXT-AWARE SHARE GUESSER
To address these problems, we developed our Mobile Media Metadata 2 (MMM2) prototype to simplify the user's experience of cameraphone photo sharing both by automating *how* a photograph is shared (through automatic background uploading and server-based photo routing) and by providing the user a computational assist in selecting *who* to share a photograph with [1, 3, 4]. Given the limitations of the cameraphone screen-based user interface, our goal was to provide a context-aware list of suggested sharing recipients that can fit within one screen of our cameraphone UI and not require either scrolling through a long list of contacts or multiple key strokes for searching through a database of contacts. In MMM2, we used the Nokia 7610 cameraphone that has a total screen resolution of 176 x 208 pixels (but with header and footer UI elements, an effective screen resolution of 176 x 143 pixels). We found we could comfortably fit 7 suggested recipients on a single Nokia 7610 cameraphone screen. We aimed to provide the right list of potential sharing recipients appropriate to the context in which the photo was captured, such that, for example, cameraphone photos taken at a child's birthday party at home would have parents, grandparents, and friends listed as suggested recipients, while photos taken at a meeting at the office would list colleagues and collaborators. We deployed our MMM2 prototype with 66 users over 6½ months (November 2004 through mid May 2005) at the UC Berkeley School of Information Management and Systems.

In the first version of our context-aware share guesser, which produced a simple sorted list of a given user's most common sharing recipients combined with a list of the people sensed via Bluetooth to be co-present at photo capture time, we correctly inferred user's desired sharing recipients 77% of the time in a computed list of 10 suggested sharing recipients.

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Using a collaborative filtering algorithm based on Sparse Factor Analysis (SFA) developed by Professor John Canny at UC Berkeley [2], we have a developed a smarter share guesser that suggests the correct desired sharing recipients within the top 7 suggested recipients 70% of the time based on analysis of a wide range of automatically gathered contextual features. The SFA context-aware collaborative filtering algorithm also supports several use cases that are important to users and that would require substantial time and effort to realize on conventional cameraphone photo sharing user interfaces:

- Easily sharing with recipients appropriate to the context the user is in (e.g., friends and family while at home, colleagues while at work)
- Sharing with co-present people the user has not shared with before

The spatial, temporal, and social coherence of the majority of the MMM2 user community also enabled the collaborative filtering algorithm to work even though we were comparing user sharing behavior based on actual user IDs, rather than types of users (i.e., user ID "1423" rather than "friend" or "co-worker"). Utilizing relations for classes of sharing recipients should improve the performance of the algorithm and enhance its scalability across larger more diverse user populations.

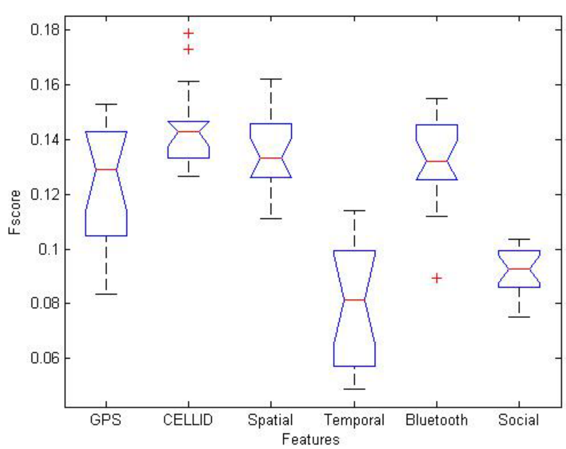

Figure 1. Error Bars and Means for Feature Fscores

Given the varying availability and power needs of different context sensors (Bluetooth, GPS, network time, etc.), we also sought to determine which contextual features provide the greatest contribution to our context-aware collaborative filtering algorithm for predicting sharing recipients. We progressively ran the context-aware collaborative filtering share guesser algorithm without certain context features in order to analyze its performance. Our results demonstrated that temporal and social metadata had the strongest effects on predictability for our dataset (See Figure 1). The most important of the two was temporal information for predicting sharing recipients. It was surprising that cellID and GPS did not have a significant effect on precision. GPS had more of an effect than cellID, however nothing that had location or Bluetooth co-presence information had a significant effect overall. This may be an effect of the sparseness of our GPS and Bluetooth information, or it may indicate that location is less important for predicting cameraphone photo sharing behavior than we had originally thought.

We developed a theoretical construct to help us understand these results: the predictability of human sharing behavior exists within a theoretical spectrum of possible correlations between observable contextual features and actual human activity. On one end, we have "prisoners" who have no "free time" and therefore whose activities are completely correlated to temporal context. On the other end, we have "lunatics" for whom temporal context has no correlation to their behavior. The predictive value of temporal context for cameraphone photo sharing behavior is an indication that our MMM2 users are closer to "prisoners" than to "lunatics," i.e., that their activities, like those of most cameraphone users, occur in largely predictable temporal, spatial, and social contexts that correlate to whom they share their photos with. Temporal context often seems to stand in for spatial and social context. For example, the weekend/weekday distinction can be highly correlative to where and around whom one is taking photos and therefore to whom one will share these photos: our MMM2 student users were in class Tuesdays and Thursdays and usually spent their weekends with other friends and family.

3. IMPLICATIONS

If the temporal context of capture plus users' history of sharing recipients can be employed to predict with whom a given user might want to share a cameraphone photo, then the possibility exists for widespread deployment of context-aware cameraphone technology on a diverse range of devices. If Bluetooth and GPS are not essential to modeling context, then the slow adoption of these sensors due their cost and high power consumption may present a reduced barrier to the deployment of context-aware cameraphone photo applications. In our future research we plan to further explore this intriguing possibility.

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