CANDELA - STORAGE, ANALYSIS, AND RETRIEVAL OF VIDEO CONTENT IN DISTRIBUTED SYSTEMS

PERSONAL MOBILE MULTIMEDIA MANAGEMENT

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ABSTRACT

Video management research has largely been ignoring the increased attractiveness of using camera-equipped mobile phones for the production of short home video clips, mostly considering them as additional channels for video consumption. The CANDELA project, which is part of the European ITEA program, focuses on the integration of video content analysis with advanced retrieval, mobile, networked delivery, and distributed storage technologies. In this paper, we present the CANDELA personal mobile multimedia management platform, which implements an *end-to-end* system for personal video production, retrieval, and consumption utilizing mobile devices and distributed databases.

1. INTRODUCTION

Increased availability and quality of integrated cameras as well as recent advances in video compression techniques and storage capacity of memory cards make it more and more attractive for people to use their mobile phones for the creation of small home video clips.

However, video management research has largely been neglecting the increasing use of mobile phones for video production in the home video management lifecycle, mostly considering mobile phones as yet another retrieval and consumption channel for already existing video collections.

Consequently, there has been considerable work so far concerning mobile retrieval interfaces (e.g., [1, 2]), video digests generation for mobile users (e.g., [3, 4]), video adaptation to mobile device capabilities (e.g., [5, 6, 7, 8]), and adaptive delivery of over mobile networks (e.g., [9]).

But more holistic views that consider mobile phones also as production tools at the beginning of the home video production cycle are still lacking.

In this paper, we present the CANDELA platform for personal mobile multimedia management [10]. The platform covers the *full* home video process from video creation, analysis and storage to personalized retrieval and delivery for various user terminals, ranging from mobile phones to PCs.

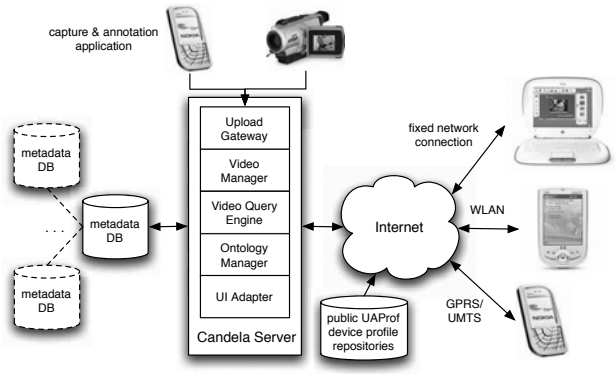

Fig. 1. CANDELA personal mobile multimedia management platform architecture

Figure 1 depicts the overall architecture of the personal mobile multimedia management platform. The platform features a *mobile video capture and annotation tool*, which facilitates the creation of video clips and their annotation with MPEG-7-based metadata [11] right at capture time on the mobile phone. Via an *upload gateway*, the tool can upload these clips into the platform's *video manager* component and their annotations into a distributed *metadata DB*. For the querying of the metadata DB, the platform offers a dedicated *video query engine*. The video query engine

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exploits knowledge about the user contained in the RDF-based [12] *ontology manager* of the platform to expand and personalize queries in order to better reflect the information needs of a user. The ontology manager permits every user of the system to maintain a private ontology describing his or her personal home video domain. Finally, the *UI adapter* component provides an adaptive web retrieval interface to the user. Using device profiles from a public UAProf device profile repository [13], the interface is able to adapt to user preferences and terminal capabilities, facilitating effective retrieval of home videos via a variety of both mobile and fixed terminals. For video playback, the *metaplayer* [14] provides a video player enhanced with an interactive metadata display for in-video browsing, helping to avoid the consumption and streaming of uninteresting video parts.

In the following sections, we illustrate the platform's major architectural components in more detail, describing the roles they play in the different phases of home video management lifecycle.

2. VIDEO ACQUISITION

For the creation of small video clips and their annotation right at capture time, the CANDELA personal mobile multimedia management platform provides a mobile video capture and annotation tool, which runs on mobile phones supporting Java 2 Microedition/MIDP 2.0 and the Nokia Mobile Media API [15].

Fig. 2. Mobile video capture and annotation tool

The screenshots of Figure 2 illustrate this tool. In a first step, the tool permits users to shoot videos clips using their mobile phone's cameras. After this, the tool automatically adds context metadata including the current time, cell ID, and, if available, the GPS position. In addition to these context metadata, a user can manually enter keyword annotations in a second stage. Keywords can also be selected more quickly from the user's personal home video ontology (see also Section 4). After annotation, the tool uploads the video and the annotations in MPEG-7 format to the CANDELA platform via the upload gateway. The gateway hands the video over to the video manager and the annotations to the metadata DB.

Alternatively, the upload gateway also supports the import of traditional home videos shot with a camcorder. In this case, users can segment and annotate the videos using the IBM VideoAnnEx tool [3].

3. VIDEO STORAGE

In the CANDELA personal mobile multimedia management platform, all videos are stored and maintained by the video manager. When receiving a video from the upload manager, the video manager extracts keyframes and creates different compression variants in different qualities to serve the needs of different output channels. For the delivery of videos to clients, the video manager makes use of the Helix DNA Streaming Server [16].

The annotations belonging to the videos of the video manager are stored in the metadata DB component, which is implemented on top of the distributed relational database management system Solid [17]. By distributing the metadata, the CANDELA personal mobile multimedia management platform obtains the scalability to accommodate the home video collections of even large numbers of users. Since the video annotations in the CANDELA platform are represented by means of MPEG-7 media descriptions, the metadata DB decomposes these descriptions into an internal relational database schema so that they can be queried with SQL.

4. VIDEO RETRIEVAL

For video retrieval, the CANDELA personal mobile multimedia management platform provides the video query engine. The video query engine accepts keyword-based searches, transforms them to appropriate SQL queries against the metadata DB, and returns the ranked retrieval results in MPEG-7 format. The video query engine is capable of personalizing queries to the user. For that purpose, it cooperates with the platform's RDF-based ontology manager.

The ontology manager manages a personal home video ontology for every user, which each user can modify and tailor to fit his or her individual home video life. As user lives and interests can be quite diverse, it would not make sense to impose a single ontology onto all users. However, the ontology manager identifies and standardizes certain general categories of concepts likely applicable to most users, such as "home", "work", "family", etc. Users can fill these high-level categories with instances from their daily lives.

The video query engine exploits the knowledge provided by the personal home video ontologies for a personalized query expansion. For example, the search for the term

"family" can be expanded to the names of all family members of a user.

The platform's UI adapter component provides a web-based video retrieval frontend to the video query engine. Based on the Apache COCOON [18] web framework, the UI adapter adapts the user interface to the individual capabilities of the terminal accessing the interface, permitting video retrieval from PC-based web browsers just as well as from mobile phone browsers. The UI adapter obtains information about a terminal's capabilities from a public UAProf registry.

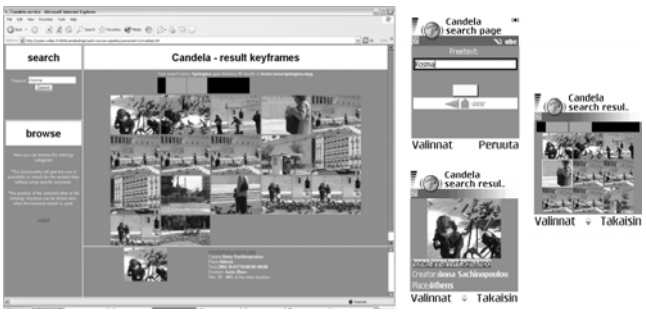

Fig. 3. Video retrieval interface

The retrieval interface (see Figure 3 for an illustration) basically permits users to either enter keyword searchs or to browse through their video collections along their personal home video ontologies. A ranked list of keyframes of qualifying videos is displayed, along with further information such as title, video format, and size. By selecting a keyframe from this list, a mosaic with the keyframes of the qualifying segments within the video is displayed. This allows users to quickly skim through the retrieval results without actually downloading videos, which might be expensive to do on a mobile phone. By selecting a keyframe, the video manager starts streaming the video to the user.

Figure 3 also illustrates the adaptivity of the video retrieval user interface provided by the UI adapter. The left side of the figure shows how the retrieval interface looks like in a normal PC-based web browser, whereas the right side shows the looks of the user interface in a mobile phone browser. Essentially, one can see that, based on the terminal profile of the mobile phone, the UI adapter has decided to break up the web retrieval interface into several screens, taking account of the phone's limited screen size.

5. VIDEO DELIVERY

Once a video has been selected for viewing, it is streamed by the video manager to the user's device via the Helix streaming server, along with information about the video segments relevant to the user's query.

Fig. 4. Metaplayer

The rendering of the video takes place in the so-called metaplayer (see Figure 4), which not only displays the video but also metadata. Synchronized with the progress bar of the video player, the metaplayer shows a metadata bar depicting the temporal positions of the segments which have been identified as relevant to a user query, e.g., those segments annotated with the keyword "child". The bar is interactive, allowing the user to easily navigate to the relevant segments in the video. The metaplayer is available for both PCs and mobile phones. The mobile phone version is based on the Hantro mobile multimedia engine [19].

6. CONCLUSION

In this paper, we have presented an overview of the major components of the CANDELA personal mobile multimedia management platform. We have shown how these components play together in order to cover the full mobile home video production lifecycle from acquisition to delivery.

Currently, we are working on extending the context-awareness of the mobile video capture and annotation tool, such that it exploits context data available on the mobile phone – like time, position of the user, the user's address book and calendar – to automatically suggest reasonable keyword annotations. We also want to integrate automatic video and audio analysis tools, so that more mid- and low-level metadata is available with the metadata DB. Moreover, we plan to enhance the personalization of the video search, introducing a personalized ranking of retrieval results based on individual user interest. Finally, we want to enhance the UI adapter with support for further user devices such as set-top boxes, so that users can browse their home videos using the most suitable devices they have available.

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