URB 12 Urban Tomography

URB 12.1 People

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URB 12.2 Overview

This project is developing an “Urban Tomography” system for capturing geo-tagged videos on video-capable cellphones and automatically sending them to a back-end server infrastructure using wireless networking technologies such as EDGE/GPRS or 802.11. Our system is designed to enable pervasive dense audiovisual documentation of city life. As our neighborhoods become increasingly diverse and complex, such documentation can enable a better understanding of social interactions and the use of urban spaces. It can also help urban planners re-structure existing cities in order to improve their quality of life.

URB 12.3 Approach

We call our system Urban Tomography, a technological framework that enables the collection and creative navigation of a large corpus of audiovisual urban documentation. Underlying this framework is the observation that relatively cheap, ubiquitous, internet-connected, mobile personal devices such as cellphones and PDAs are increasingly equipped with good video capture technologies and GPS. These technological advances promise pervasive sensing of urban phenomena: we envision swarms of trained volunteers spreading out across a cityscape and regularly recording urban processes for extended periods of time. Casual users can also contribute to the corpus. These audiovisual records can be transmitted over the network for near instantaneous analysis by anyone with access to the global Internet.

To enable Urban Tomography, two advances are necessary. At the “back-end”, the acquisition, transmission, storage, and indexing of audiovisual records must be made as automatic and transparent to the user as possible. A simple back-end will require less training and thereby enable more pervasive sensing by more people. However, this is technologically challenging because of the scale of the problem: a potentially large number of video clips introduces technical challenges in robustly distributing the corpus to ensure high availability, and organizing information to enable intuitive navigation and fast searching of the corpus. The second set of advances requires audio-visual display technologies that simultaneously present inter-related urban processes with the aim of challenging the viewer to find previously unsuspected relationships between the perspectives. This is analogous to tomography, which attempts to simultaneously explore multiple perspectives (“slices” or “cuts”) of an object (an
organ, a geophysical feature) in order to reconstruct the object in its entirety. In our case, we are exploring techniques such as split-screen and multi-channel sound to present these multiple views in a creativity-enhancing way.

**URB 12.4 System Description**

Our prototype system consists of two major components: the capture and transmission software on the cellphone, which captures video files and automatically (without user intervention) transfers them to a server. The server contains a database that stores all video files and its metadata, as well as a simple web viewer which displays a group of videos as “small multiples” using tiles.

Our capture subsystem is designed for the Nokia N95 phone. This phone has a 1GB micro-SD card, supports 640x480 high resolution video and has “Assisted” GPS functionality. Our videos are stored on a commodity server machines running the Apache web server and a mysql relational database backend. In turn, the capture subsystem includes a user interface process which allows the user to access the camera, configure the application, or examine the application log. The main user interface process on the capture subsystem also associates the current video recording with metadata. This metadata is stored as a separate file, and contains timestamp and GPS location associated with the captured video clip (more precisely, the GPS location of the phone at the end of the clip). A background process is responsible for transferring video files to the server. It periodically scans a designated location on the local file system, and if it discovers any video files, attempts to transfer the video to the server system. This happens automatically and without user intervention. Since wireless connectivity can vary dynamically, and large file uploads are more likely to be interrupted by intermittent wireless connectivity, the background process breaks large video files into chunks to ensure forward progress for file upload. In addition, the background process monitors available forms of network connectivity (whether the GPRS network is available, or which of many hotspots are available). It prefers to use a WiFi hotspot if one is available, but otherwise attempts to use the GPRS network.

**URB 12.5 Accomplishments**

Our system has been operational for several months. In this time, we have completed several field experiments of the system. Here is a partial list of such field experiments.

- May 08: Swarming on the UCLA Campus, CS219 by Prof. Estrin’s students.
- Oct. 08: SPPD Parents Weekend, USC by Prof. Krieger.
- Oct. 08: METRANS 10th Anniversary.
- Dec. 08: OSU employment in Katrina sites.
- Dec. 08 ~ Jan. 09: Tokyo.
- Jan. 09: Beijing by Prof. Govindan.
• Jan. 09: SPPD 80th Anniversary, USC by Prof. Krieger.
• Mar. 09: Initiation of security application by a transportation site in Los Angeles.

The project webpage http://tomography.usc.edu also includes several other field experiments.

Related works

QIK (http://www.qik.com/)

QIK supports streaming service from the phone. Users can create their own content and stream it directly to the server. Other users can see them in real time with small delay. But they support lower quality than we do and do not support to show multiple videos at one place.

The Visual History Archive (VHA) of the USC Shoah Foundation Institute. (http://college.usc.edu/vhi/)

The Visual History Archive (VHA) of the USC Shoah Foundation Institute for Visual History and Education is a video archive of testimonials from Holocaust survivors and witnesses offered through the USC Shoah Foundation Institute. The archive includes nearly 52,000 video testimonies of Holocaust survivors, witnesses and liberators collected in 32 languages and from 56 countries by the USC Shoah Foundation Institute. The archival purpose is suggestive for our project, although our use of sensors is distinctive. They are not using cellphone as a collecting device, and also don’t support multiple display.

URB 12.6 Future Directions

There are several research challenges in this project.

The first is that the system does not use the best performing network available. It sometimes uses an unreliable wireless access point even if there are better ones available. Large file uploads are adversely affected by this. A simple solution is to use some form of “link estimation” to continuously ensure association with high quality access points. One way to do this would be to obtain access point signal strength (this is currently difficult to do on the Nokia cell phones because, even though the OS tracks access point strength, third party applications do not have enough privilege to access this). Failing this, we could empirically determine link quality by determining the rate of progress on a connection, and decide to switch if this rate of progress is deemed inadequate.

The N95 has a very short battery life. Under continuous video file upload, it loses its complete charge in about two hours. While battery life will improve with future generations of phones, there is scope for energy-saving techniques: putting the phone into energy-saving modes when a network is unavailable, choosing good quality network connections to avoid energy wasted in lost-packet retransmissions, and so forth.

A well-known problem with GPS, of course, is that it does not work inside buildings and other obstructed structures. Our software currently tags captured videos with the last obtained GPS reading, which is currently acceptable for our purposes.

There are interesting challenges in being able to synchronize tiled 6 to 9 videos — OS overhead adds noticeable delays between tiles. These shortcomings motivate several interesting future directions of research, some of which we intend to pursue in the coming year.

URB 12.7 External Research Partnerships

Prof. Jennifer Cowley, Ohio State, documentation of post-Katrina Mississippi. (current)

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