CO-451

TIMELINE: A TOOL FOR THE VIDEO ANALYSIS AND VISUALISATION OF GEOGRAPHIC PHENOMENA OVER TIME

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ABSTRACT

The growing number of webcams and their rapidly improving quality provide the researchers in Cartography and in other fields of Geography with a valuable source of information, i.e. webcam recordings can be used to study many kinds of geographic phenomena. Nevertheless, the use of tools such as webcams raise a question about the appropriate time scale needed to identify and study different kinds of geographic phenomena. In this paper we present a web tool called TIMELINE that can be used to collect, archive and visualize various geographic phenomena at different time scales using recorded imagery.

INTRODUCTION AND BACKGROUNG

Cartwright (1999) argued that cartography should explore the possibilities offered by the advances in distributed multimedia technologies. He outlined how the “New Media” provide new ways to communicate geographic information, using new metaphors that are complementary to the map metaphor. One year later, Monmonier (2000) described how webcams can be used to enrich the information presented by maps, and how these images can provide the user with important insights into the phenomena related to the entities represented on a map. Since their first appearance in 1991, webcams have grown in number and improved in quality. Nowadays, a vast amount of webcams are available all around the world, easily accessible from any web browser, monitoring traffic jams, tourist attractions and natural phenomena. Altogether, they represent an incredible source of information about a large variety of spatio-temporal phenomena, and a valuable opportunity for researchers in geographic information science (Johansson, 2008, Dee et al., 2009), environmental science (Richardson et al., 2007, Nagler et al., 2009), and social science (Timothy and Groves, 2001).

Webcams are a valuable and rich source of information for documenting and monitoring geographic processes, however, it has to be taken into account that different geographical phenomena appear at different time scales or are only observable in certain instants (an instant is a temporal primitive that expresses a moment or a point in time). Different temporal granularities, instants and intervals of observation can lead to the identification of different sub-phenomena even when investigating one major phenomenon. If there are several phenomena in the study, this effect gets further amplified. For example, one can take into account three different phenomena and regularly measure a variable for each of them at the same instant. If they possess the same value at that instant (with no further observations) one may conclude that all the phenomena behave similarly. Consequently, inferring from that particular instant on an aggregated level and concluding that the value should be the same for every instant during a given interval, one may fall victim to ecological fallacy. If an urban place is crowded every day at 8 am, for example, it does not have to be that it is crowded the whole day. The threat of ecological fallacy has to be considered not only with spatial scale, but also when working with time scale. Therefore, when interpreting results obtained based on webcam recordings, one should be aware that the results depend on the instant of observation and time interval during which the measurements occur as well as on the used temporal granularity.

As Edsall et al. (2000) pointed out, the exploration of complex spatio-temporal data demands creative methods for analysis. Understanding geographic processes requires more than knowing its spatial extent, and its periodicity can provide additional insight into the geographic phenomenon (Edsall et al., 2000). The use of multiple temporal granularities provides an essential support to extract significant knowledge from spatio-temporal datasets at different levels of detail (Camossi et al., 2008). Moreover, Chua et al. (2000) observed that various types of video transitions can be modeled as temporal multi-granularities phenomena. Given the same data (e.g., a series of images), the temporal granularity may be fine or coarse; therefore recordings may differ only in their time scale. For example, a phenomenon which may not be observed at a coarse temporal granularity could become visible at a finer temporal granularity of the same video stream. This leads to the hypothesis that for different phenomena, the same time temporal granularity, instant or time interval may not be appropriate for observation.

In this paper we present a new web-based tool, named TIMELINE. This tool has been developed to systematically collect image streams recorded by webcams, to enable qualitative analysis of geographic phenomena at different time scales, and visualize them as animations. In order to test TIMELINE, two different case studies are presented and the related results are discussed. Finally, possible future developments of the tool are proposed.

THE TIMELINE WEB TOOL

TIMELINE has been designed as a website to assure the highest system compatibility and to gather the web-based data conveniently. At this point, the TIMELINE website is not publicly available, however, once the testing phase is over, it will be. The main functionalities are: the creation of webcam-archives, the automated collection of images, and the creation of animations. A set of configuration options allows the user to control the time scale of the animations created using TIMELINE.

The back-end of TIMELINE is a MySQL database (MySQL 2010) that provides three tables where the collected images and the created animations are stored. The prototype was implemented using the PHP (PHP 2010) scripting language. To separate the logic from the presentation, the Smarty template engine (Smarty 2010) was used, which allows the creation of different templates. These templates are filled with variables passed from the script. The front-end of the framework is running on an Apache web-server (Apache 2010), through which the user's browser connects. The front-end is responsible for all the user interaction.

To create an archive (see Figure 1), the user has to specify the URL of a webcam of interest and a name for the new archive. As soon as a user creates a new archive, the relevant data is written to the database. Then the tool starts to collect new images by mean of a cronjob (Cronjob 2010) executing a script every 5 minutes. This script selects all the webcam-archives in the database and grabs a picture from each URL. Each image is downloaded and stored on the server, and a new image-record is written to the database.

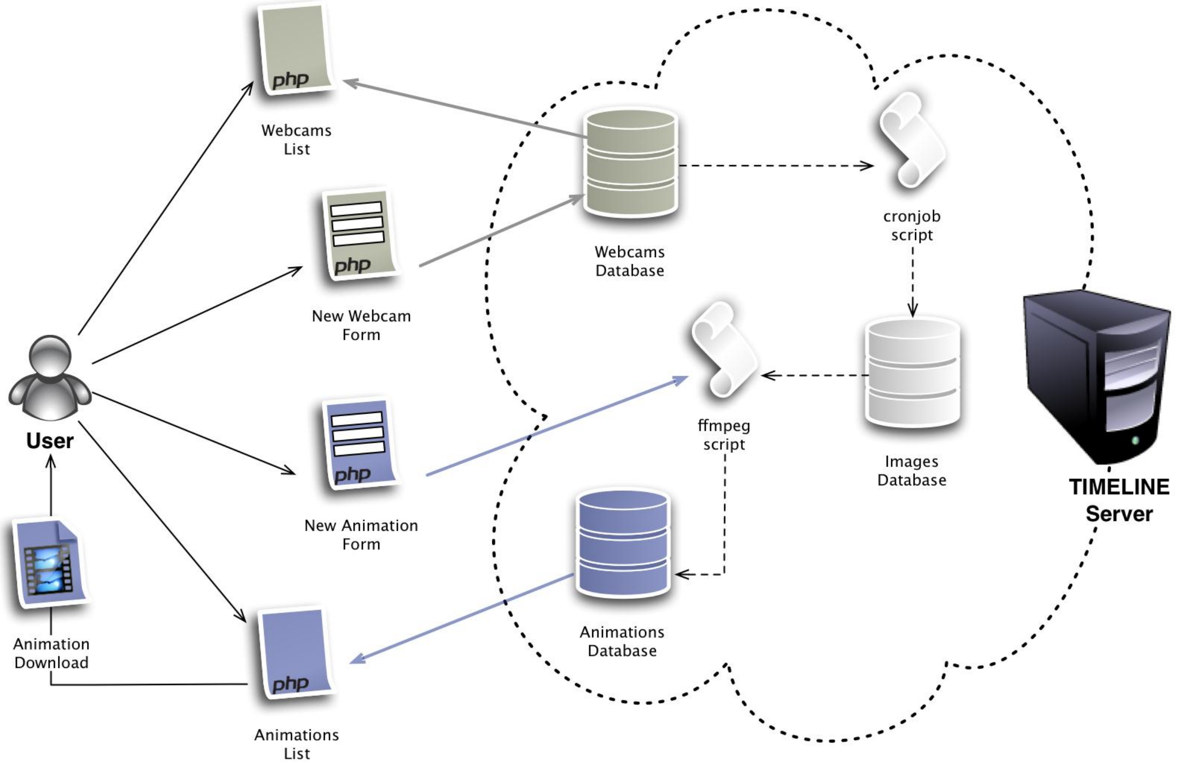

Figure1. The TIMELINE system architecture and user interaction flow.

To create a new animation, the user has to choose a time interval (i.e., a starting instant and the maximum number of pictures), specify a temporal granularity (e.g., if "5" is specified, every fifth image is taken and the resulting temporal granularity is one image every 25 minutes) and select how many frames per second should be displayed in the animation. With these options the user can control the content, the duration and the frame rate of the animation. These variables have been defined as dynamic variables and are used to control the image replay (DiBiase et al., 1992). The user can either create a new archive (and wait until the desired number of pictures for the animation has been collected) or use an already existing archive to create a new animation. For each requested image, the related information is retrieved from the database and a symbolic link to the file is created. Then, the script runs the ffmpeg command (FFmpeg 2010), in order to create an xvid-encoded avi-movie with the given parameters. The created animation is stored on the server and the related information is written to the database. Finally, the users can access, view, and download the animation for further analysis.

CASE STUDIES AND RESULTS

To demonstrate the current capabilities of TIMELINE, two different case studies and the related results are presented below.

Case Study 1: Main Railway Station Leipzig, Germany

To investigate the bustle on an urban place, animations with the same temporal granularity but of different time intervals were compared. Furthermore, other animations from the same webcam were analyzed in order to show how it is possible to get completely different results using different temporal granularity and time intervals, and how some phenomena are visible only at a proper time scale. Depending on the topic under investigation with the webcam looking at the forecourt of the main station of Leipzig, only with very specific adjustments to the starting instant, the total duration of the interval, and the temporal granularity, it will be possible to get an animation suitable for identifying a given phenomenon.

For example, looking at the process of installation of the Christmas lighting at the main station building, if one chooses a short interval (e.g., five hours), one will only see a part of the process (or maybe not even identify it). On the contrary, producing an animation over three days, and visualizing it at faster rate (e.g., 10 fames per second), one will not see all the movements of the crane (used for the installation process) anymore but will be able to identify the whole installation process (see Figure 2).

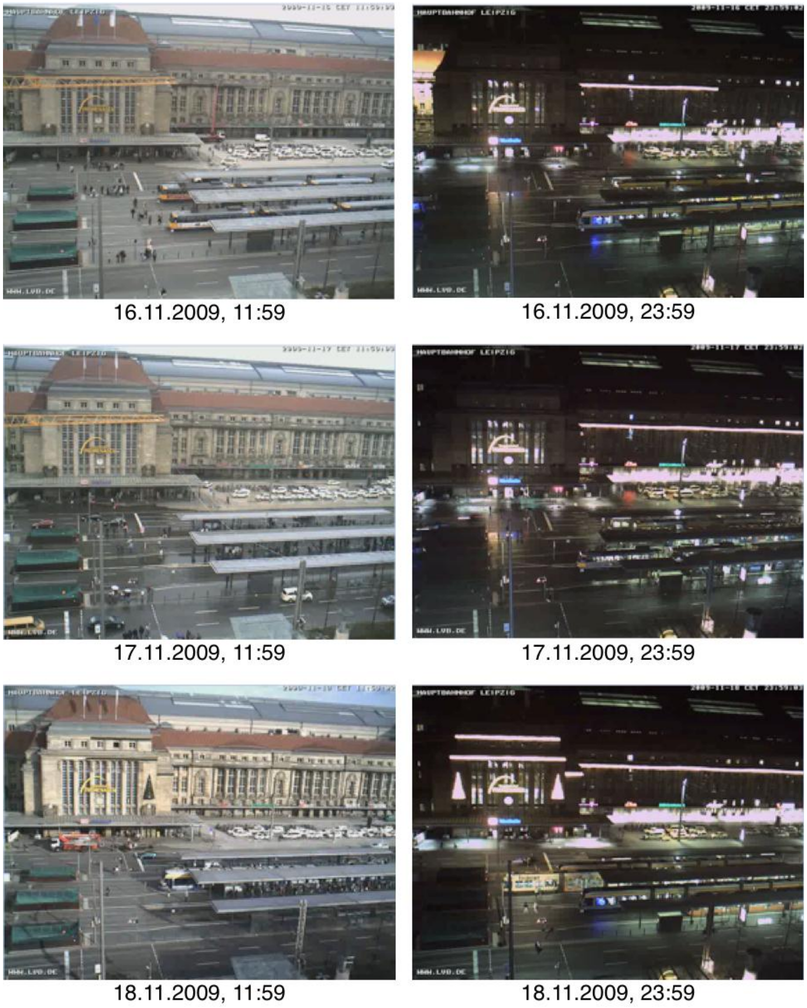

Figure 2. Installation of the Christmas lighting at the Leipzig Main Station.

URL: http://ewerk.tv/lvb/LVBHBF/lvbhbf.jpg.

In a second example, we produce two different animations that differ in their temporal granularity, where the intention is to observe the amount of taxis available at the railway station (e.g., for defining the operation schedules for a taxi company). The first has the finest temporal granularity available in the database (i.e., 12 pictures every hour) and discloses the course of one day, starting at noon. From this animation, the amount of taxis at a chosen instant of that day can be extracted. In the second animation, using a more coarse temporal granularity of only one picture a day, at the same time of the day, it is possible to figure out the average number of taxis over a period of four weeks. This allows an estimation of the usual number of taxis at a certain time of the day. This example demonstrates that, with a proper parameterization of the TIMELINE tool, it is possible to identify a phenomenon and gain additional information about it.

Case Study 2: Triftgletscher, Switzerland

The purpose of this second case study was to find a proper time scale for analyzing glacier movements, a phenomenon that can only be observed over a long-term monitoring. A glacier in Switzerland (Triftgletscher) was observed on a daily basis using an existing webcam (VAW, 2010). After a month of data collection, an animation was created, however no changes could be detected.

Two other archives collected over three years (Maisch, 2010) were used for comparison: one based on the same webcam and another based on a camera showing the same region from another point of view (VAW, 2010). Looking at the images from the first of these two archives, it was possible to identify the melting and freezing of the glacier's lake over the course of one year, but it was not possible to identify the movement of the glacier (see Figure 3). Looking at the images from the second archive, with a temporal granularity of one picture per day, one main process was detected. At this temporal granularity, the floating of the glacier was perfectly visible. At the same time, focusing on the surroundings, it was possible to spot the accumulation and the melting of the snow. Finally, using a coarser temporal granularity of approximately one picture per month in an animation that includes pictures of many years, the decline of the glacier could became visible. This highlights how TIMELINE can be potentially useful for analyzing and communicating the effects of global warming and environmental processes alike.

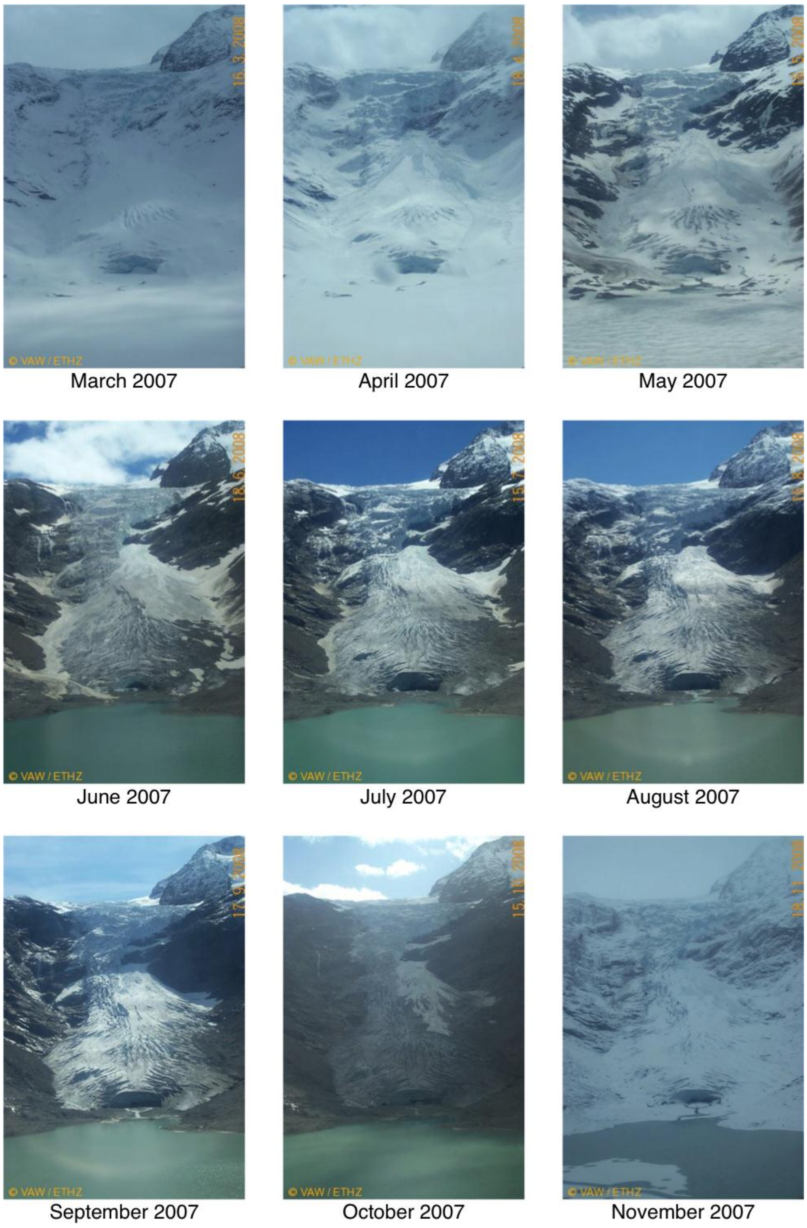

Figure 3. Melting and freezing of the Triftgletscher glacier's lake over the course of one year. URL: http://people.ee.ethz.ch/~glacier/images/trift_acam1.jpg.

CONCLUSIONS AND OUTLOOK

In this paper we presented TIMELINE, a new web-based tool that aims to help the analysis of large webcam archives for the visualization of geographic phenomena at different time scales. The two case studies presented above outlined the functionalities of the tool. These examples show how geographic phenomena can be identified and additional related information can be gained using a proper time scale and a related set of values for the tool parameters. The case studies also highlight how the identification and analysis of the geographic phenomena can be strongly influenced by the instant in which the images are captured, as well as the time interval and the temporal granularity. Therefore, the results obtained from the tool should be tested with users for interpretation accuracy and the users should be educated as to how they can make meaningful inferences.

The tool will be modified in order to allow the users to assign a custom frequency for the collection of images. This will enable processing of a given archive for a specific purpose and preventing the tool from collecting potentially the same picture several times if a camera records the picture only at a certain frequency. A second improvement will concern the creation of metadata. This will provide to a broader public an easier understanding of why a specific archive was created, what the intentions were and which settings were chosen. In a long-term perspective, we plan to investigate the available technologies that could bring feature-recognition capabilities to the presented tool. This will allow the users of TIMELINE to perform not only qualitative but also quantitative analysis of the geographic phenomena captured by the webcams. TIMELINE will be made public after the improvements mentioned above.

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