

# PATHMARKER: SYSTEMS FOR CAPTURING TRIPS

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## ABSTRACT

Central to capturing a trip is knowing where you were, and when you were there. Combining continuous path data with media (*Path-Enhanced Media* or PEM) offers substantial advantages over the previous approach of tagging individual media with time and location. Prototype systems, collectively called *PathMarker*, are used for gathering, editing, presenting and browsing PEM. We developed 1) a methodology for gathering PEM with off-the-shelf hardware; 2) software for automatic conversion of the raw path data and media into an application independent XML representation; and 3) two example PEM applications. The first application provides map-overlaid trip editing, presentation and browsing. The second application provides a 3D immersive environment with digital elevation maps for automatic trip flybys and for browsing. Experience with a number of recorded trips confirms that *PathMarker* systems seem to capture the essence of a trip.

## 1. INTRODUCTION

The decreasing costs of electronics makes it possible that location and time data will be available via GPS [1], cell phone service infrastructure [2], or indoors [3] in the near future. Combining media with continuous path, the converse of recent research that tags images with location [4, 5], offers a number of significant advantages. Accurate paths allow for the 1) automatic creation of an organized, rich media diary that helps people remember, enrich, share and relive past trips and helps them to plan for new trips; 2) embellishment of trips using third party stock media and non-media information; 3) the natural, automatically created presentation of trips; and 4) new kinds of media annotation, sharing, dissemination, search and organization. The PEM data represents the core information of a trip, and it may be used in different applications such as viewers, editors and automatic multimedia publishing systems.

This paper describes prototype systems for editing, presenting, and interacting with PEM and it describes results of experiments with these systems. A companion paper [6] describes the *MediaBeads* architecture for capturing, representing, editing, presenting and searching PEM data -

enumerating additional advantages of path. That paper includes the example of interactive DVD creation from PEM. Capturing vacations is used as the application in this paper, but *PathMarker* is useful for many other consumer and business needs. For example, it would be useful for real-estate agents building map-based multimedia presentations of homes for sale and real-estate clients reviewing weekend home tours.

## 2. GATHERING PEM WITH OFF-THE-SHELF HARDWARE

For our experiments, PEM was gathered using off-the-shelf hardware. A GPS receiver provides the path (time and location) data and digital cameras are used to gather images, video and audio. The Garmin *Etrek Summit* GPS receiver was used in the experiments. This receiver is compact, stores several thousand trackpoints and has sufficient battery life for more than one day of travel. Various digital cameras were used to capture time-stamped media.

The GPS receiver time, in conjunction with the local clock of the camera, is used to compute the correct location for inserting media into the PEM structure. This requires that the local clock of the camera be synchronized with the GPS receiver clock. Once this is done, then separate upload from the two devices is possible and software to generate appropriate position information for the media captured allows the generation of the PEM for subsequent manipulation and presentation by the different software applications.

This method of gathering path and media simplifies design of future, integrated products, since the path and camera hardware then require only minimal “contact” for time synchronization, and may even be electrically isolated.

## 3. MERGING MEDIA AND LOCATION DATA

Once the media and path data is gathered, the next step requires merging the data into PEM. A software component, written in Perl, automatically merges the raw uploaded GPS trackpoint data and the digital media files generated from the digital camera. This software calculates the latitude and longitude bounding box for the trip, queries an

online map server (map servers such as MapServer and MapPoint are systems that return maps given geographic bounding boxes) to retrieve geographic or aerial map backgrounds. Alternatively, the program incorporates a user-provided map file with given latitude and longitude extents. The path and digital media are adjusted to account for local time zone differences. Additionally, map overlay information is encapsulated by the program into an XML control data structure, together with a directory structure for storing the supporting media and map backgrounds. The XML data structure has, in addition to the path, media and map components, the information required for presenting the data as different user defined “layers” of media.

#### 4. PC MAP-OVERLAID DYNAMIC PRESENTATION AND EDITING SOFTWARE

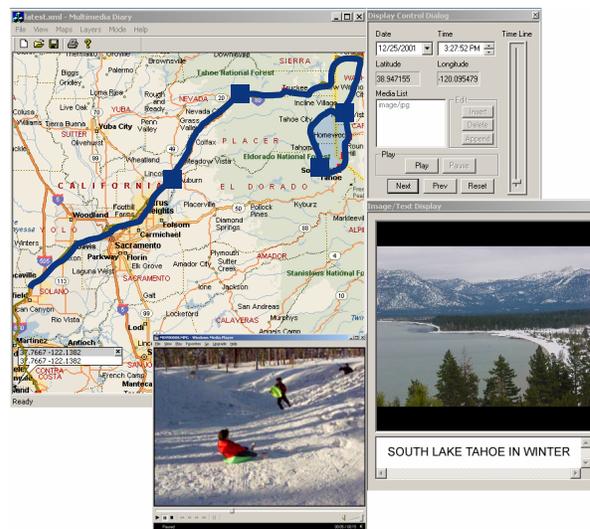
The first software application, written for PC, allows the automatic replay of a trip, the map-based random access of media and path elements of a trip, and the annotation and embellishment of a trip by insertion or deletion of media on the path. The program is multi-threaded to enable simultaneous user interaction with the various display window at the same time that the path is retraced during playback.

When the software runs, the user may select a trip to review, may play the trip automatically or alternately may randomly access the trip content using the map-based graphical user interface. The user may select different map backgrounds types and different “layers” of media, meaning media acquired into different user-defined categories, for the presentation. For example, a vacation may be separated into historical sites and art museums. The different “layers” may be viewed using geographic or aerial background maps.

The program allows map based-graphical editing of the trip, allows the modification of the trip record by allowing the insertion of new media, such as audio annotations, text, images or videos and in order to delete unwanted media.

The software allows the dynamic, automatic replay of a trip. In Figure 1, a screen shot of the software application taken halfway through the replay of the trip is shown. The figure shows four windows that may overlap. The top left window shows the map-overlay presentation of the path taken. In this window, a portion of the path traveled lies on Interstate Highway 80 in California, heading from the Central Valley towards Lake Tahoe. The path is drawn as a line on the map, and square icons show the location of digital media such as photos and videos. In the computer

display, the partial path already traveled and the media already viewed are shown in bold. The map overlay window allows the selection of different map backgrounds and different “layers” of media organized into different categories. This window shows the traversal of the path during playback of the trip, and it also allows random access interaction with the trip content using mouse clicks on the path or on the media icons. The top right window shows the control window, displaying date, time and position information and information about the media being viewed. The control window contains controls such as “play” that allow viewing the entire trip, including retracing portions of the path taken, the viewing of the photos, videos and other media at the appropriate positions and the continuation of the path retracing between media elements. In addition, the control window, together with the map-overlay window allow the selection of media to insert or delete during editing. The lower right window shows a still image viewer, together with a text annotation viewer. In the figure the text “South Lake Tahoe in Winter” is seen below a digital image of the lake. The lower center window is a media viewer, showing a frame from a video of a child sledding in snow.



**Fig. 1.** A screen shot of the PathMarker viewer and editor showing four windows, from top left in clockwise order: 1) interactive map view of path and media icons 2) control window 3) still image window with text annotation and 4) video and/or audio media player window.

We gathered PEM data from about fifteen trips. Experiments using the viewing software are now described using representative trips. The first trip was recorded on

the Stanford University campus. This included a twenty minute stop indoors at the Stanford Bookstore. It is well known that GPS signals deteriorate indoors, but this trip confirmed that as long as one enters and exits a building at the same point, or in other words, the signal is lost and regained at the same point, then the overall presentation of the path is acceptable. In this example, even though GPS signal reception weakened, the trip path record still clearly highlighted the bookshop stop.

A second trip covered a larger geographic region, involving a car trip from the San Francisco Peninsula to Lake Tahoe. Figure 1 shows that this PEM follows the highways and the outline of Lake Tahoe very well.

A third trip involved traveling on foot and by bus in San Francisco, where GPS receivers may not function well near buildings because of signal occlusion or multiple path reflections of the satellite microwave signals. The San Francisco PEM recorded well most of the trip. In one portion, however, while the traveler was on a bus the GPS signal was apparently lost. This resulted in a loss of accuracy of the path display for that portion. Nonetheless, the overall results of the map display were deemed acceptable.

In these trips, interestingly, there were events that the PEM record helped the traveler to remember. For the Stanford campus trip, for example, two scallop shaped portions of the path indicated the place where the travelers were lost trying to gain entrance to the art museum. Another example involved the San Francisco trip, where a small detour occurred when a misplaced library book was found on the ground and returned to the library.

The editing features of the software were successfully used to annotate one of the trips in order to generate a self-contained demonstration of PathMarker. A self-contained CD-ROM was thus created that explained the PEM technology using audio annotations, gave directions about the use of the software as well as presented an example trip. Customized presentations were easily modified, based on the same underlying PEM, to either present the users the audio annotations, or alternately present the original trip without any annotations.

## 5. INTERACTIVE THREE-DIMENSIONAL PATH-ENHANCED MULTIMEDIA

The second software application developed incorporates Digital Elevation Models (DEM) [7] in order to explore the extensions needed for three-dimensional interactions and flybys of PEM. The graphics implemented used the OpenGL™ Graphics API on a PC. Figure 2 shows three screen shots from this system. The figure shows in the

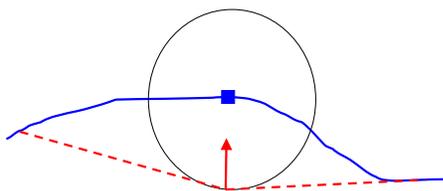
background a conventional city map texture mapped on a three-dimensional elevation model of the region. The “billboards” in the figure show media content that correspond to photos, videos, etc. at the locations they were taken. The viewer’s location and view direction in a 3D world are either interactively controlled or automatically provided through preset flybys.



**Fig. 2.** Four views of a PEM flyby with a city map texture-mapped on a Digital Elevation Model background. The figure shows a simplified path traveled together with *billboard* representation of the digital media.

A flyby or walkby retraces the path taken, in this case in a three-dimensional model of the world, and replays the media at the appropriate positions and times. With this system, since the media lie on the path traveled, and both path and media are viewed through a single window, retracing the path in a conventional manner results in “collisions” (intersections) with one’s media. Collisions are not a problem for the previous software system, described in Section 4, because path and media are viewed in separate windows. To avoid collisions in the current system, a “looking-around” algorithm modifies the path to go around the media, and pauses to view each medium. Figure 3 shows the action of the algorithm. A solid line shows the original path, with a square icon representing multimedia shown on it. A dashed line shows the modified portion of the path. The arrow shows the view direction during which a short pause in the path traversal takes place. To create the modified path, a circle is conceptually drawn around the media icon. A new waypoint is determined to be the nearest point a prespecified distance away from the

medium that lies tangent to the current path. The orientation at this waypoint simply points toward the medium. A second waypoint and orientation, consisting of the same values but with delayed timestamp, is inserted into the path to ensure that there is a pause to view the multimedia at this location. In the end, the modified path ensures a smooth flyby that stops and “views” every medium without collisions.



**Fig. 3.** The “looking-around algorithm”. The original path is shown with a solid line, with a square media icon on it. The modified portion of the path is shown with a dashed line. The arrow shows the view direction during which a short pause in the path traversal takes place.

An experiment with the 3D software is described using PEM data from the San Francisco trip. For this experiment the path was edited to simplify its presentation. Screen shots of the trip flyby are shown in Figure 2. When the DEM representing the topography of San Francisco is exaggerated and a conventional city map is texture-mapped on top of the topography, it provides additional 3D information that is useful for planning and discovery. The first experiment with the DEM data for San Francisco showed a hill in Golden Gate park unknown to us, causing us to question the accuracy of the elevation data. The hill, known as Strawberry Hill, was verified to exist during the trip. The flyby replay of the trip, together with the “looking-around” algorithm, provided the feeling that one was traveling and viewing billboards with one’s media. Some viewers found the 3D flyby and walkby version of PathMarker to be entertaining as well as helpful in reviewing a trip.

## 6. CONCLUSIONS

The aforementioned experiments show that “off-the-shelf” GPS devices and mapping software are sufficiently accurate for envisioned consumer and business applications. The PEM presentations provided a rich record of a trip both for participants of the trip as well as for non-participants.

Participants were, in several instances, reminded of events during the trip by the path context. Non-participants gained a richer experience of the trip because they retraced the path, and therefore saw the media in context. The maps, together with the latitude and longitude of the corners, resulted in well aligned maps without any manual adjustment. Thus, we have shown that the “upload” step for PEM may be easily automated.

Having rich media become a property of the trip path provides an interesting type of media that allows for uniform methods of interaction throughout a trip cycle of planning, capture, organizing, sharing and reliving.

The software prototypes described in this paper provide basic PEM capabilities which proved helpful to people in capturing trips. If PEM becomes widely available, issues of scaling, organization, browsing, searching and sharing this new type of media come to the forefront. These research areas involve the topics of geometrical query algorithms, representation of spatio-temporal objects and map-based human-computer interaction.

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