The Experience Re-player: Trail-based Reconstruction of Captured Experiences in Ubiquitous Computing Spaces

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ABSTRACT

In this paper, we describe the Experience Re-player, a system that uses smart-phones to record experiences of a visit. Such experiences are augmented with additional multi-media content and reconstructed digitally in the form of an interactive website. Experiences can be replayed, searched, stopped and restarted, annotated and edited to act as an aide-de-memoir and to extend the relationship between places and people. We show how trails used as data primitives are a critical element in the successful construction of the Experience Re-player. Finally, we present two cases studies in which we used the Experience Re-player within a museum exhibition setting.

Categories and Subject Descriptors

E.2 [**Data Storage representations**]: Composite structures, Contiguous representations, Hash-table representations, Linked representations, Object representation. H.3.3 [**Information Search and Retrieval**]: Information filtering, Query formulation, Relevance feedback, Retrieval models, Search process, Selection process.

General Terms

Algorithms, Performance, Experimentation.

Keywords

Trails, memory, visitor studies, stochastic models, probabilistic grammars, suffix tree, spatiotemporal data mining.

1. INTRODUCTION

Three aspects of smart-phones make them powerful devices to enable pervasive computing [5]: their auto-identification capability, that is the fact that their wireless interface can be used as a unique identifier transparently for the user; their integrated camera which allows for the capture of video and still images; their secondary wireless local networking capability via Bluetooth; and last but not least, their ability to record and transmit voice messages (locally or over the cellular network). In this paper, we employ these capabilities to develop the Experience Re-player (ER), a system that records the trail of a visit and recreates it in the form of a personal website.

In the case studies that we have developed, the visit is to a museum exhibition but the concept can be easily extended to trade fairs, retailing, shopping malls, and a variety of similar situations. The ER can also be seen as a generalization of the Remember concept [2] which allows for richer interactions with the environment, integrates associated external multimedia content, allows editing the experience record and supports reflection. We develop two ER applications: a tool for editing, annotating and sharing of experiences and a tool for visitor studies.

2. USAGE SCENARIOS

To highlight the different elements of the ER and to best describe its operation we present several scenarios that collectively define the system First, we discuss the Experience Recorder that collects events related to a particular experience with a specific environment; then Navigation Engine which reconstructs experiences into trails and then the post-processed applications of Experience Re-player itself which replays the record and also supports post-action editing and annotation; and finally, the Visitor Analyst which can be used to aggregate and analyze recorded trails so as to gain a better understanding about common behaviors.

The Experience Recorder. The Experience Recorder captures visitor experiences within some specific space. Consider the scenario of a museum visit that may be part of a class field trip, a family outing, or just a casual visit. On entry, visitors register their smart-phone so that the system can recognize them and associate experience data with their identity. Visitors then proceed with their visit as they normally would and the Bluetooth interface of their phone interacts with access points embedded in the exhibition space to record their activities completely transparently. Moreover, whenever they wish they can request the device to (i) record multimodal audio-visual annotations to their experience (for example a comment about an object or their impressions of an event), (ii) give a command to the Experience Recorder system, for example to instruct the system to bookmark a specific location, content, object, or interaction. All recorded events are filtered and stored by the Experience Recorder and associated with the identifier of the visitor(s). On exit, visitors receive information on how to retrieve and use the record of their visit.

The Navigation Engine (NE). The Navigation Engine is at the core of every ER system as it is the component that creates structure out of distributed and disparate recordings and repositories. The NE creates an integrated model of all content captured during the visit and relates it to particular user interactions and experiences. Moreover, the NE is responsible for the processing of all audio-visual input and creates and maintains the global repository that captures the whole domain structure. Given the critical role of the NE within any ER system, it is particularly important that it can cater for large amount of data and can respond efficiently to a variety of queries. This leads to a rather complex core engine design the details of which go beyond the scope of this paper [4]. Finally, the operation of the NE is transparent to the user as it is working "behind the scenes" to provide the context aware functionality that powers user applications.

The Experience Re-player. The Experience Re-player (ER) is the application which provides access to visit data which can be reconstructed in different media. The ER also combines such records with associated content held in external digital information and audio-visual content repositories. Notably, the ER reconstructs the experience as a web application which combines spatial visualizations and multimedia content (cf. Figure 1). Other reconstructions are also possible, for example in the form of printed material or three-dimensional fabrications.

A prototype design of the ER is shown in Figure 1 and has the following elements: it contains a map of the exhibition and the trail followed by the visitor is overlaid on the map. This hyper-textual trail record also contains links to audio-visual objects held in the museum or external digital libraries or other web enabled collections management systems, related to the exhibits that were inspected and to other relevant material. The trail also contains user generated audio and video content as well as three-dimensional object representations requested by the visitor during the visit when setting bookmarks. Trails can be replayed from start to finish or step-by-step while at the same time associated information from the digital repositories will be displayed to correspond with the recorded visitor location. In particular, particular objects are represented on these visualizations as links to associated information.

Furthermore, the user is able to edit the trails to add their own material (either recorded during the visit by additional devices, collected from independent sources or providing personal views and interpretations and other content created during the visitor). This system capability is seen as an effective way to support learning through the experience replay via reflection and also by evolving the interpretations of the material. On subsequent visits to the same space the new trail record will be superimposed on the existing one, thus creating a continuity of experience and incremental knowledge attainment.

Finally, the system supports sharing of experiences in different ways. In its simplest form, experiences can be shared by replaying a recorded visit for others to see – this might be especially useful in the context of school group visits with particular learning outcomes which can be explored and further developed during the replay. A second mode of sharing is by asking the ER to overlay the activities of a whole group of people in a single visual representation. In this way, they can compare experiences and use this as the basis for co-construction of interpretations.

The Visitor Analyst. While the ER offers new opportunities for extending access beyond the spatial and time confines of the visit, it can play a central role in the development of improved access strategies for the museum by refining its understanding of visitors. Indeed, the information collected in visitor navigation sessions can be used within visitor studies focusing on all facets of the visitor experience and its informal learning implications. Over the past two decades visitor studies have made substantial contributions in improving our understanding and enhancing visitor experiences in informal learning settings through research, evaluation, and dialogue and bring forth a vision for cultural heritage organizations based on a view of the world where lifelong learning is embraced, and where learning in informal settings benefits individuals, communities, and society at large.

The data collected by ER can go along way towards helping organizations understand their audiences by providing a wealth of information which previously was impossible to collect using traditional, manual techniques [3]. For example, in Figure 2 we show a visitor density map that shows how visitors use the museum space during an average day. The ER can create such representations and support analysis at different levels of granularity to help investigate the evolution of usage over extended period of time without the staff resources required to do this using traditional techniques.

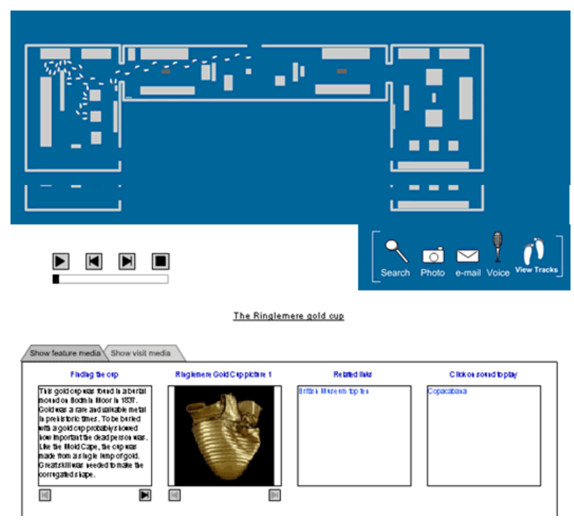

Figure 1. The Experience Re-player application.

3. TRAIL-BASED RECOSTRUCTION

Our main concern when developing the ER system has been the information management aspects of such recording, archival and retrieval. In particular, we aim to show that an appropriate data management approach can be developed on top of the digital equivalent of the conceptual experience record, which we call a *trail*. A trail brings together the different aspects of the real experience for example what the visitor saw, what they thought, and what they did. Consequently, trails are in many cases the mental mechanism with which individuals organize and recall their personal experiences. For this reason, trails suggest themselves naturally as an appropriate candidate for the role of the data primitive on which to build an archival and retrieval engine for personal experiences. Moreover, trails have the additional advantage that they can be displayed within a temporal context, possibly also combined with the spatial attributes of their recording context.

Furthermore, the use of trails as a data primitive allows to easily associate records of a personal experience with related digital resources held on object repositories, potentially maintained online. Such links between artifacts and digital metadata offers the opportunity to augment personal experience records with semantic information, for example artifact descriptions, production and usage history and other cultural information. To this end, we develop a general data model that can be used to record, archive and reconstruct personal experiences and a suitable representation of the intelligent environment tailored to this task [4].

The view of the ER as an extension of the cognitive capabilities of the individual is hardly new. As long ago as 1945, Vannevar Bush outlined his conception for such a machine which he called the memex. The memex would store unlimited amounts of information interlinked in different ways, a concept that has been revisited in recent years in work on hypertext systems. Bush also described two core aspects of the memex: first, how users would buy information and add it into their memex; and how old and new information would be linked together forming associations. In fact, this associative way of locating and retrieving data was one of the main ingredients of his vision. He viewed such association as the appropriate way to support memory as he believed that the human mind retrieves knowledge by following trails of association rather than by indexing and querying (this is a central difference between information retrieval by the human mind and a database). Trails have an intimate relationship to context as they operate within a particular semantic domain associated with particular activities. His proposal was exactly aiming to assist retrieval following the current user context. Bush also suggested that users could add their own annotations to the information of a trail, so they could navigate along such trails of information and access personal notes.

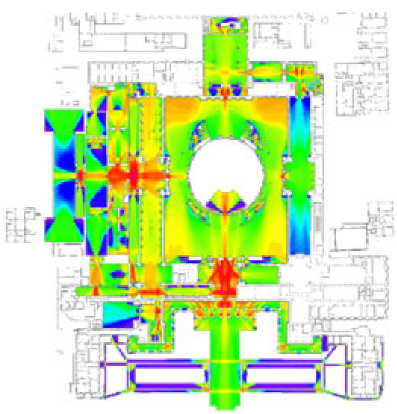

Figure 2. A visitor density map computed via trail aggregation.

While trails as an information organization mechanism have been rediscovered several times since, each system has adopted a working definition and resulting structure to fit the particular problem context. In the ER we introduce our own definition of trails in a way suitable for navigation in intelligent environments: we treat unstructured or semi-structured information items as nodes and the associations between them as edges in a graph structure constructed on the fly by the system. Nodes are either associated with particular physical artifacts or represent interactions with resources locate at a particular URL on the web. Moreover, nodes contain links to additional meta-data which are also semi-structured and pertain to user annotations. This later feature tracks closely the memex concept in that it links into the experience record so-called “standard information” in Bush’s terms (that is information available to the public) as a core source of content and the user adds personalized notes. However, in the ER the knowledge base building process follows the opposite path in that nodes are selected as a result of user activity and subsequently augmented with public information.

The reason why trails are an appropriate primitive for navigation is due to their relation to landmarks as a way finding mechanism. Indeed, one of the most useful tools in navigating both physical and conceptual spaces is the use of landmarks that is, material or digital entities that act as reference points for the relationships between the user current and target contexts (for example spatial location, object under examination, its properties and available modes of interaction, video recoding, web page, database record or view, or concept into consideration). Using landmarks, a user can take short cuts between their current and target locations within a particular knowledge repository and thus become able to effectively and efficiently locate the required resource. Even in cases where way-finding activity reaches a dead end, the user does not have to start their session from scratch but only to go back a few steps to a recognized landmark and attempt to follow a different path. Landmarks also provide a deliberate way to pass on information to others about the route to a particular resource.

In the case of pervasive environments in particular, there is ample evidence to imply that a user succeeds in learning or memorizing a given hypertext environment depending on the amount of landmarks and the number of retained relations between them [1]. This conceptual and visual representation of the underlying network structure is indeed a powerful mental tool in navigating situations and problem solving. Yet, in a conceptually organized information space, for example in any knowledge ecology, remembering landmarks and their relationships is a strenuous activity. In fact, even in cases where such relationships have a clear spatial representation, their conceptual/associational nature implies that in most cases the mental resources required to establish coherence and meaningfulness would overwhelm even the most able user, especially within tight time constraints.

The ER solution is developed around its reconstruction-visualization features which recast the captured experience in terms of a story-line or narrative, and thus tap into the inherent capabilities of humans for storytelling. To do this, we introduce a natural mapping between a node in a trail and an event in the corresponding narrative. This allows us to take advantage of the rich network of spatial, temporal and causal relations that lie at the core of understanding and experiencing narratives, and thereby supporting navigation. We propose that the introduction of narratives -- controlled by the user via the ER interface -- allow users to establish a more coherent experience. Such narratives are constructed automatically by the ER by collating data to first identify landmarks, which are subsequently used in step two to form a mental map of the experience. The final step of this navigation approach is to use the constructed maps to acquire routes to specific knowledge resources.

4. CASE STUDIES

We have implemented the ER in a fully functional web based system which we tested in two case studies: an indoor environment based on the Blipsystems platform (http://www.blipsystems.com/) at a simulated exhibition at the British Museum; and an outdoor intelligent environment developed using GPS-enabled smart-phones at the London Zoo. In both cases, there exist considerable on-line databases of multi-media content that refer to the collections held, and these were heavily used.

In the first case, the Blipsystems Bluetooth infrastructure was used to track and time visitor proximity to specific features and to record interaction events. In this case, it was necessary that the infrastructure be installed and maintained by our project. Visitors carry a variety of Bluetooth devices that were used to identify them but also to potentially record voice and images that were collected by the infrastructure and recorded as appropriate.

In the case of the Zoo, visitors carried mobile devices with GPS capability and were able to bookmark locations and record images. In this case, it was necessary to carry out considerable pre-processing to identify interactions between features of the environment and visitors but ultimately the same server system has been employed to reconstruct and visualize the recorded trails.

For each case study, the system requires that descriptions of the intelligent environment (a visual representation as well as spatial constraints expressed as SQL spatial primitives) are provided including the location of it features as well as their associated media (the later may be given simply as hyperlinks to appropriate URLs). Then visitor and trail data must be uploaded thus triggering a dynamic process that creates the experience player visualizations.

The server processes that implement the interactive application are developed using J2EE technology, which creates the relevant reconstructions. As part of the visualization process, the web application also creates Macromedia Flash visualizations of the experience player. Although the use of the later may not be the most appropriate solution, especially with regard to accessibility issues, it nevertheless provides a clear way to programmatically generate appropriate animations via its Actionscript feature. Note that in our current implementation, the ER application is generated on the fly in Actionscript at the time when the user attempts to access the application.

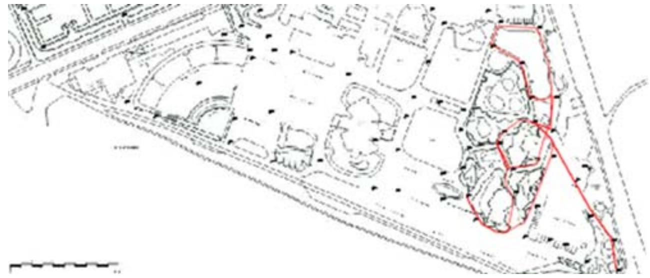

Figure 3. A detailed via of a single visitor trail at the Zoo.

5. CONCLUSION

In the paper we have described the Experience Re-player a system that uses smart-phones to capture visitor experiences at a specific location. We view this system as a way to extend the relationship between visitors and space beyond the spatial and temporal confines of the visit itself and as a tool to support reflection. We have also highlighted the application of the system for

6. REFERENCES

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