LARK: Location-Aware Personalized Travel Guide with Rich Knowledge

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1. ABSTRACT

We present LARK, a mobile web application at edu.lark.gr, that provides location-aware information content. LARK is a query-search-optimization engine that serves as a multimedia database, an individually customized tour planner and an on-site tour guide. Technically, LARK consists of a server component to facilitate generation, modification, search of multimedia content that can be related, and adaptive, to physical locations and a mobile app to render and adapt the tours on user's mobile device(s) and interests. LARK provides new possibilities for collecting and sharing specialized knowledge beyond tourism, by presenting tours with high educational and historical significance for its users.

2. INTRODUCTION

LARK is a mobile web application at edu.lark.gr, to provide a new experience with personalized tour planning and on-site guidance. Many modern museums offer visitors audio guides to certain themed sections via provided players, and recently, via mobile web applications. At a much larger scale, with much richer information, offering personalized customization, LARK accompanies and guides anybody with a mobile device, a smartphone or a tablet, to a city or county and enriches the travel experience with enlightening and delightful information.

LARK utilizes synergistically modern technologies and techniques for sensing and processing. Smartphones, or similar mobile devices, can accurately identify location, access the Internet, and playback audio and video content from various sources. LARK acts as both a personalized tour planner and an on-site personal guide to new or familiar destinations facilitating tour plans ahead of time or in the spur of the moment. Aware and adaptive to spatial location, LARK can guide a tourist, an adventurer or a student, on foot or vehicle, not only describing locations and directions, but also providing information on local tales, legends, history, architecture, arts, customs, shopping and services. Everything is done at a personal pace, by personal taste and interests (Figure 1).

The content of a guided tour can be extended and enriched to a variety of themes beyond conventional tourism. Special thematic walks can be accessible at any time and not only when the specialists are

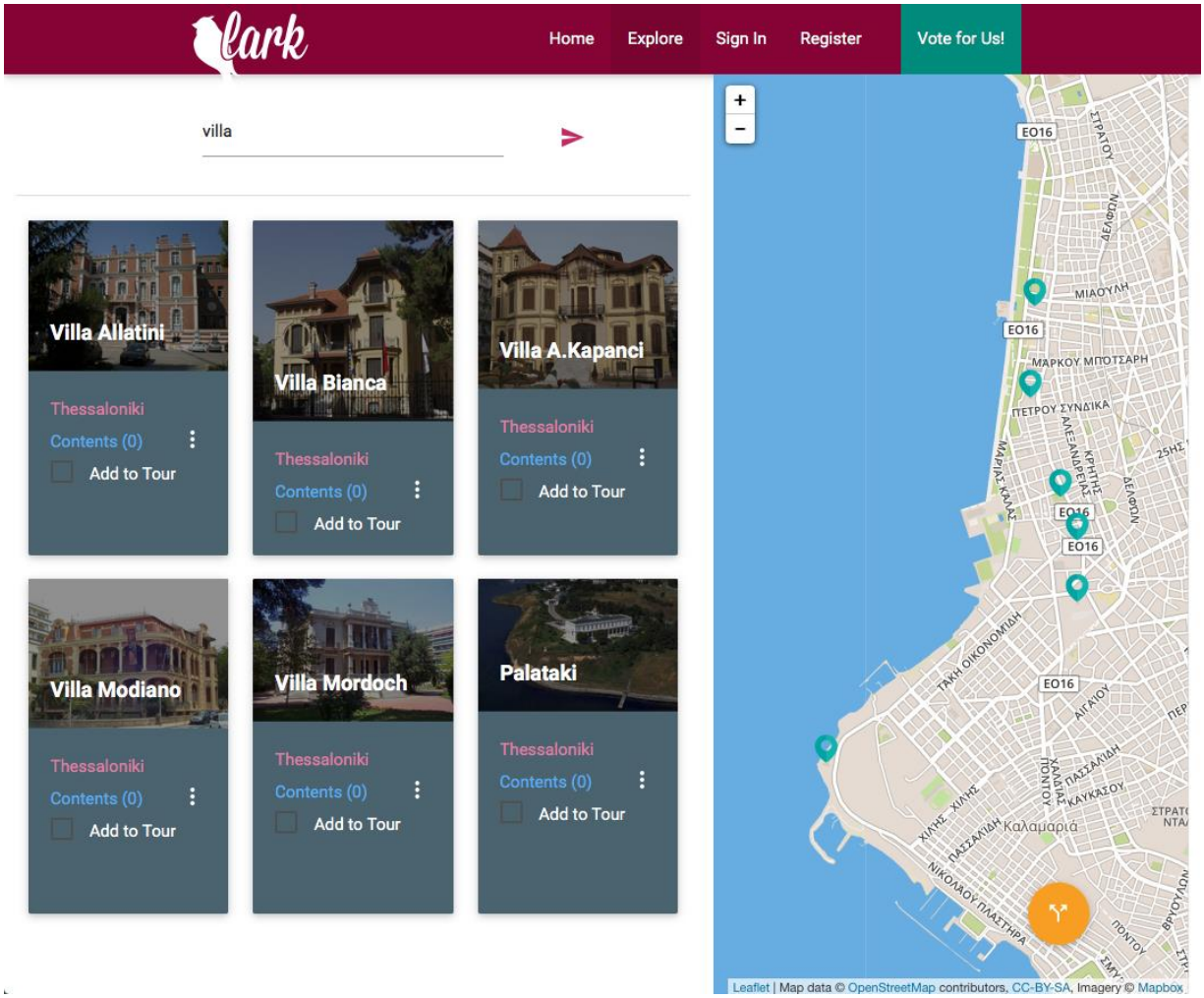

Figure 1: Screenshot of LARK, showing the results of a query. Resulting articles are shown on the left panel and their associated locations are shown on the right map panel.

available. A tour may contain the localities related to the life of a poet, the house she was born, the school she attended, the coffee shop she used to frequent. The audience can trace the poet's steps from place to place, listening to poetry readings along the way and gain new insights to her work. The guided tour may be the audio performance of a play, the non-linear reading of a novel, or even a treasure hunt game, where the action is triggered by the places visited.

3. RELATED WORK

Recent years have seen the emergence of many mobile touring applications that take advantage of the multimedia playback and geocoded information. Among audio guides, *Acoustiguide* (2014) provides multiple mobile phone applications that guide the user through a specific city, or site.

The *Kawamura Memorial DIC Museum of Art* application contains audio recordings that provide explanation to various artworks and introduce the visitor to the history of the museum.

The *Richmond Olympic Experience* (ROX) application consists of a complete audio tour, accompanied by insightful commentary by Olympic and Paralympic medalists, granting knowledge to the tough journey an athlete takes in order to reach the Olympic Podium.

City of Perth iWalk Trails (2015) incorporates three different audio trails, in order to entertain and brief the user about the history and culture of Perth city. Among video guides, *Timetraveler The Berlin Wall Augmented* (2014) tries a different approach. Instead of audio tours, it enables the visitor to revisit and experience historic events by overlaying photos and information on the walls of the buildings and sites, through augmented reality. The traveler can therefore see historic footage of the same locations on their smartphone screen.

Guide content can be enriched in many ways. For example, *Walking Cinema: Murder on Beacon Hill* (2013) provides a mixed reality storytelling mechanism that while presenting and narrating the story of the murder of Dr. George Parkman, it guides the user through geocoded videos that reveal the evidence and the story of the incident. The application acts as an interactive storytelling game, but also explores real locations around historic neighborhoods in Boston, to communicate with the audience in a more direct manner.

Dopios (2015) tries to connect visitors with citizens of the city they are exploring in order to provide specialized tours along multiple landmarks and sites. *Dopios* works as an intermediate channel, so that travelers can find their local guide, who shares their interests and is willing to tour them around the city

Research papers on the making of such guides can be found in related literature. *LifeMap* (2011) and *Cyberguide* (1996) provide a basic infrastructure, regarding context-aware content and multimedia in order to effectively accomplish the creation, storage and redistribution of the application's data to the end user. This is of the utmost importance, since building a framework that will enable the incorporation of previous mentioned features in one unified solution, requires appropriate database abstractions and design.

A study is also carried out on the effectiveness of tour guides via guide-user interaction. A context-aware Tour Guide (2007) studies the impact user feedback can have on the robustness, and investigates, --from a usability perspective--, the differences between context-aware tour guides in contrast to conventional applications.

4. CONTRIBUTION

The purpose of LARK has been to inherit multiple aspects introduced by different applications and to combine them under one user-friendly framework, without losing necessary abstractions. LARK is a unified platform that enables the generation, modification, distribution, customization and rendering of location-aware, information-rich content in the form of self-guided tours. It marks a substantial advance, and a departure from existing tour guides that provide only pre-determined, theme-specific, location-specific, fixed and limited information content, and render content in a fixed form or format.

LARK is easy to access, as a user or creator, without the need to consult programming experts or any requirement to build place-specific applications. Open or copyrighted content can be created and shared with others through LARK by people with little or no technical background. LARK also strives to create and connect user communities to author original material that is hard to uncover otherwise.

The LARK framework is underlaid by a well-designed abstraction and configuration, integrating and implementing the desired features. The technical contributions of LARK are summarized as follows:

- A framework designed and developed to facilitate the generation, storing, distribution and rendering of multimedia, multi-source content, that is associated to geographic locations.
- Automated classification and characterization of landmarks and sites, exploiting information collected via crowd-sourcing.

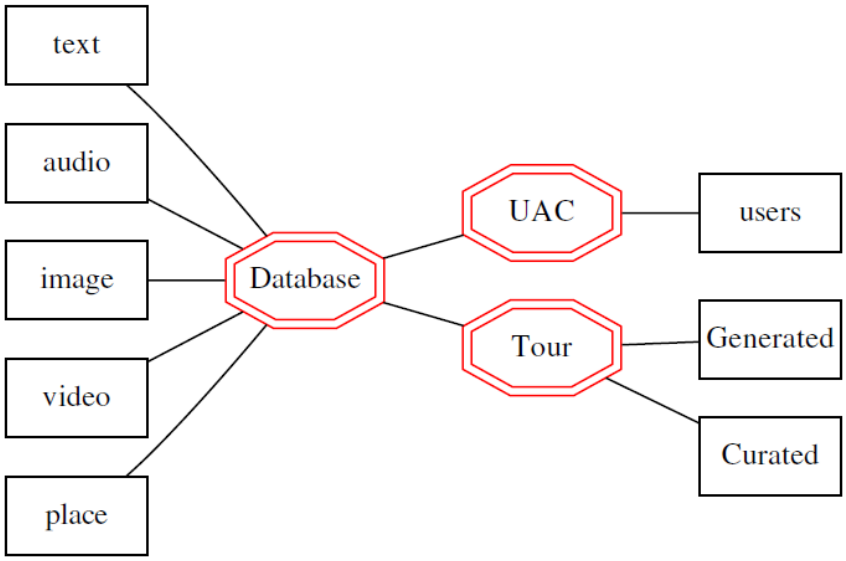

Figure 2: Screenshot of LARK, showing the results of a query. Resulting articles are shown on the left panel and their associated locations are shown on the right map panel.

- Automated generation of mobile tour guides customized to the user's schedule, pace, tastes and interests.
- Collection of direct and indirect user feedback.

5. SYSTEM COMPONENTS

LARK consists of three major components. A multimedia database, a subsystem for managing user access, and an optimizer for tour planning and guide rendering (Figure 2).

The multimedia database with associated locations is the main component feeding all services provided by LARK. The LARK database of multimedia, in addition to text, contains voice narration, music, photographs and video associated with a geographic location or position in an indoor space like a museum. The entries provide information that can be browsed in advance, or just in time during a tour. Audio files with voice narration free the user from having to look at the mobile device. Music selected and timed appropriately prepares the audience for the upcoming point of interest and creates the right mood. This content can either be accessed on-demand or be programmed for automatic playback.

The database also contains categories that can be mapped to information. Points of interest are annotated with multiple category attributes that map them to classes of general or specialized interests like history, architecture, nature and many more that can be defined by the users, directly or indirectly.

The system of user account management is a database of registered and anonymous users. Locations and descriptions can be created, modified, and reviewed by users. Thus knowledge and expertise can be shared with everyone who is interested about a certain place. User annotations are also recorded; these include commentary and grading of existing information, and categorization of entries into classes. User records contain voting history, annotations, editing of entries or tours taken.

The tour optimizer is a special service module of LARK. In its simplest form, the tour optimizer solves a scheduling problem to minimize the distance or time traveled to reach all target locations of a tour. More complicated problems are solved when additional constraints are added. For instance, time windows may be imposed on the tour stops, for example, the time a certain attraction is accepting visitors and the overall duration of the tour is constrained. Traffic conditions and means of transportation may also be taken into account to form an acceptable tour.

Interactive tours can also be generated, based on position, path and the user's recent interactions, resulting to a unique experience. This provides a form of interactive narrative tours, that do not always produce the same final route, but change and adapt, based on user's choices.

6. INTERNAL PROCESSING AND LEARNING

The internal abstraction and processing in LARK are as follows. Locations are denoted by nodes and paths by edges in a graph. Both nodes and edges can be associated with classes and multimedia content. Content assigned to edges is filtered depending on the transportation means. Related content can be triggered according to proximity or similarity criteria.

Advanced computational techniques are used to characterize the nodes, to generate tours and collect feedback from the user. Nodes are automatically classified into multiple classes in order to associate them in different ways and themes. Each node is denoted by a vector in a d-dimensional space, where each dimension represents a different attribute (i.e. historical value). The attributes are elicited or crowd-sourced from user feedback. A k-means classifier is used to categorize each node into classes for node classification and characterization. Neighborhood clusters can be provided as alternative suggestions that might interest the user.

After the classification process, correct labeling of the derived clusters is also very important, in order for the application to provide correct results. The labeling process can be enhanced through the use of the Latent Dirichlet allocation (LDA) algorithm on the content or the reviews of a specific site. LDA can identify common topics along multiple documents that accompany a place and use these to correctly identify each cluster.

The customized tours are spawned through the use of both the user's current location and the classes that best match user interests and subjects queried. The suggested route minimizes the overall distance or time needed to traverse the tour. The scheduler takes into account the distances between places, the form of transportation, real time traffic conditions, probable amount of time spent in each node, opening hours of the places to be visited and the user's available timeline.

LARK collects and learns from the user feedback, without the user's direct involvement or with user's direct feedback or contribution. For instance, the application records whether the tour was completed, how much time was spent en-route and at each location. If a location visit has been prematurely terminated or completely omitted, the user is queried to reconfirm an interest in the subject. The user feedback, direct and indirect is used to better associate attributes to nodes, so that this information can be utilized in future tour planning.

LARK enables and encourages the user to participate in recording and sharing information related to points of her interest.

7. CONCLUSION

Creation of multimedia materials in addition to text, containing voice narration, songs and music, photographs and video related to a location and their reproduction in sequence and on queue for a self-guided tour has become very easy with the ever-expanding capabilities of mobile technology. Combining technologies like the Global Positioning System, Wi-Fi position estimation, and maps with such multimedia can lead to the creation of easy-to-use, high quality, context-aware applications.

LARK interconnects all of these with the appropriate abstractions in order to provide a unified platform for travelers and guides, containing the tools to create, distribute and render multimedia tours around the globe.

By making connections to visitors, LARK aspires to also have positive impact on local communities, on local people in all walks of life, and open new and exciting opportunities to sustain and advance local culture, arts and business.

LARK is available at edu.lark.gr, and accessible from anywhere the Internet reaches.

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9. AUTHORS' BIOGRAPHIES

Spyridon Bontomitsidis is a graduate (2015) of the department of Electrical and Computer Engineering of Aristotle University of Thessaloniki. His strong interest in software led him to work outside of his degree and gain experience in web-programming, android developing and algorithms. Adding that with the hardware expertise acquired from the University, he formed a true engineering profile, able combine software and hardware efficiently. He worked for nine months at IMEC, Belgium implementing his thesis, which gave him the opportunity to design professional level hardware and software, adding value to the existing cutting edge research work. In addition, he is part of Meerkat, a developing team, with distinctions in various national competitions on smart applications to improve everyday life and tone up tourism.

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Dimitrios Floros is a Ph.D. candidate in Electrical and Computer Engineering at Aristotle University of Thessaloniki, Greece. He received his diploma with excellence from the same institution in 2015, with a thesis on the analysis and design of 3D projection mapping systems. His primary research interests lie in the field of high performance numerical computing. His enthusiasm with software developing led him to become part of an award winning team, Meerkat, developing web-apps as well as mobile applications that help solving everyday live problems. He has also worked for Passias S.A., developing and updating the existing inner-company ERP system.

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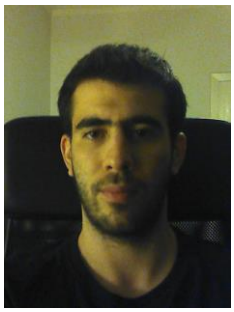

Konstantinos Mylonakis is a student of department of Electrical and Computer Engineering of Aristotle University of Thessaloniki. Currently working on his thesis in the field of Fast Multipole Method. Besides his interest in the field of computational physics, he enjoyed to expand his developing skills learning about Web developing and system administration. His enthusiasm for dealing with complex real life problems led him to join the Meerkat team, where he works on back-end and algorithm tasks. He has won three awards as members of Meerkat team for the application Prisma, Aneas and Lark and looks forward to improve the existing projects and deal with new challenges.

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Dimitrios Manolas is finishing his studies in the department of Electrical and Computer Engineering of the Aristotle University of Thessaloniki. He is presently working on his thesis on energy efficiency through behavioral economics. Dimitrios has channeled much of his engineering problem-solving background into new areas and ventures, taking a strong interest in the managerial and marketing fields. He had the opportunity to develop his competences further by working for 6 months for Procter & Gamble. For the past two and a half years, Dimitrios has also been strongly involved in volunteering, by taking key positions in the Erasmus

Student Network, Europe's largest student organization for the advancement of mobility and international higher education.

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Nikos Pitsianis is an assistant professor with the department of Electrical and Computer Engineering of the Aristotle University of Thessaloniki, Greece. His research experience and interests are in algorithms and architectures for high performance numerical computing and applications in integrated sensing and processing. He holds a PhD in Computer Science from Cornell University.