Active Visitor: Augmenting Libraries into Social Spaces

Zois Koukopoulos
Dept. of Cultural Heritage Management and New Technologies
University of Patras
Agrinio, Greece
zkoukopu@upatras.gr

Dimitrios Koukopoulos
Dept. of Cultural Heritage Management and New Technologies
University of Patras
Agrinio, Greece
dkoukopoulos@upatras.gr

***Abstract*—Apart from their definitive role in the preservation of the treasures of human thought, libraries offer scientific, educative and entertainment services to their visitors. With the competition rising every day from various different sources, traditional or not, like the Internet, libraries should elevate their services in order to retain their position in an everyday changing world. Our contribution to the field of digital systems for libraries is Active Visitor, a system that offers both AR and social services to the visitors of a library. The system was designed taking into account the user requirements of library personnel and visitors. Active Visitor aims at the engagement of a library visitor through advanced AR services that permit book annotation through a mobile app and the sharing of such information at broader communities through specific social services. The system implementation is based on current AR technologies in order to offer services to library visitors through their smartphones. However, it can support modern wearable technologies like AR glasses which is the next step to the human computer interaction technologies. In order to stress the strength of the proposed system towards users' satisfaction a quantitative and qualitative evaluation methodology is performed. Evaluation results suggest that the proposed system is an efficient attempt towards a system that transforms libraries into active digital social environments, while it offers a new avenue for additional revenue for libraries.**

Keywords—libraries, social networks, augmented reality, user engagement, personalization

I. INTRODUCTION

Nowadays, each new day seems to unveil a new technological achievement which aspires to change more or less the lives, activities and habits of modern people. A new reality is shaped every day creating new needs and new pursues. Along with the appearance and domination of a new technological advancement, like the smartphone or the social media in the 2000's, a massive wave of changes pushes markets, industries and institutions towards a new reality. Established institutions like libraries need to evolve in order to remain interesting and useful to an audience that craves for modern high quality services [1, 2, 7].

Augmented Reality (AR) is one of the most promising contemporary technologies that has the potential to utterly change how people react with the real world, practically transforming reality to an enhanced digital environment full of interesting and useful information [3, 4]. Inserting AR services to library spaces could be a step towards transforming traditional libraries to live ecosystems where the physical world (books, facilities) is enhanced with digital content providing a series of advantages [8].

A series of research questions arises. Would library visitors appreciate AR services in a library environment? What kind of AR services would be more interesting or useful for library audience? Would such services attract more visitors to a library and increase visitor engagement? Is it feasible for a traditional library to provide AR services from a cost, space requirements and ease of use perspective?

Following the road of innovation why would libraries stop in the adoption of a single technology? The tremendous acceptance and domination of Social Media (Facebook, Twitter, Instagram), highlighted the need of modern individuals for social interaction with their peers and strangers, through technological means [9, 10, 11]. Libraries should be able to satisfy the need of their visitors for digital socializing, while visitors use library's facilities and content [5, 6]. As mentioned in [7], libraries "aspire to be public places, open to a vastly larger public, to individuals and groups". Similar research questions require further study. Would the offering of social services have a positive impact on visitors' numbers and engagement? What kind of social services would be more interesting for library audience?

In this work, we present Active Visitor, a system that offers engaging, personalized and immersive social and AR services to library visitors aiming at the optimization of user experience during a library visit, prolonging the visit's time and the personalization of book reading. In order to work properly, the system requires and supports the active participation of the library staff in collecting, storing and managing rich library content, by offering specific services designed to be operated by librarians. Through the system's modules, library visitors can interact with the book they are reading in real-time by creating AR annotations linked to specific book phrases, share their annotations to other library visitors reading the same book, view their personal and other visitors' public annotations and form small social networks engaging in discussions with other visitors. Library visitors can use those services through their personal smartphones by simply installing the library's dedicated mobile application minimizing the cost of technological equipment for the library. Additionally, library visitors can obtain a digital version of the book they were

978-1-7281-0292-4/18/$31.00 ©2018 IEEE

reading, including all personal and public annotations linked to that book, with respect to the book's copyright restrictions. We perform a qualitative and quantitative evaluation of the proposed system services and characteristics in order to investigate the relationship between user engagement and specific social and AR services within a library environment. The sample consisted of library visitors and librarians to gain perspective from both user types. Evaluation results indicated that the proposed system services contribute positively in building a mutually fruitful relationship between a library and its visitors. Moreover, evaluation results indicated that AR services could be an additional source of revenue for the library.

Active Visitor tries to relieve the fear of users that their annotations, discussion messages or library book content will be accessed and manipulated without their permission applying suitable authorization mechanisms. In particular, we extend role-based access control model to impose limitations to the access of user content in order to enhance the trustworthiness of the proposed system towards its users.

II. RELATED WORK

Interestingly, AR is referred to as a technology that every librarian should investigate and conquer, in [3, 4]. Reference [12] investigates current literature on AR services for library environments (HP Reveal [13], EON Reality [14], Layar [15]), discusses with professionals the benefits of using augmented reality services in a library and concludes that such technology should be seen as a valuable means to increase audience engagement. User engagement through generic AR cultural applications has been a particular field of study by many researchers [16, 17]. Reference [18] takes a deeper dive and argue that an acceptable and successful AR cultural system should work in any circumstances, provide personalized services, be easy to use and provide useful information.

Various notable research efforts have produced systems, platforms, frameworks, applications and tools that offer augmented reality services to libraries. Reference [19] presents a recommender app with augmented reality services that is able to recognize call numbers on a book in the library and suggests relevant items that are not shelved nearby. Moreover, in [19] user experience results are demonstrated, along with the discussion of specific considerations on the future development of personalized recommendation functionality. Geolocations [20] is an AR app where users scan Uppsala city and navigate to ten different library buildings of the Uppsala University. A mobile augmented reality application for book spine recognition on library shelves is presented in [21]. The application offers both visual and audio augmentation for books on shelves and implements various well-known algorithms for AR tracking and registration achieving very low recognition latency, a crucial factor near instantaneous augmentation.

An important aspect of security in open digital systems is the application of authorization actions to the users when they attempt to access content. This goal can be achieved applying access control models like role-based access control (RBAC) [24]. A digital system for libraries stores both text and multimedia content. An authorization model specialized for multimedia content stored in musical heritage archives is presented in [23]. Reference [22] describes an extended role-based access control scheme which applies on multiple files on digital art projects.

III. USER REQUIREMENTS

The system aims at satisfying the needs of two different groups of stakeholders: the library staff and the library visitors. In order to extract each group's requirements and aspirations from such a system we formed two different focus groups. The first focus group included 20 experienced librarians of public and university libraries. The second group included 20 individuals from general population that may visit or a library or not. Afterwards, we designed specific questions for an open interview consulting a group of 5 specialists in the field of library research. Then we performed a series of personal interviews with the members of each focus group. This study led us to determine a number of requirements a perspective user has from a modern digital system for libraries that offers social and AR services. In particular, librarians mentioned that such a system should not bare significant cost or occupy large spaces. Such a system should be easy-to-use for the library staff, contain all library content in digital form, increase the number of visitors, engage visitors for longer times and generate additional revenue for the library. On the other hand, library visitors indicated that such a system should be user-friendly, easy-to-use and costless. The system should not require purchasing additional equipment from their behalf, and it should allow some short of interaction between them and the library books. Furthermore, visitors mentioned that the system should permit the transfer of the work they are doing during their visit outside the library space. Additionally, visitors emphasized that such a system should encourage the exchange of opinions about a book they are reading with other visitors forming a social ecosystem.

IV. SYSTEM DESIGN

A. System Architecture

The system architecture consists of three modules: the local server (LS), the management desktop application (MDA) and the visitor mobile application (VMA). System architecture is illustrated in Fig. 1.

Local Server: The LS consists of three layers, the Network Layer (NL), the Processing Layer (PL) and the Raw Data Layer (RDL). NL serves as an intermediator between the LS and the end-users. End-users connect their devices (smartphones, tablets, AR glasses, PCs) to the library's Wifi and post/request data to/from the LS through the MDA and VMA. PL consists of a CPU that implements all the necessary system operations, exchanges information with the NL and the RDL manages user-created AR annotations, embeds new annotations to instances of the physical book's digital versions and manages social discussions between library visitors in real-time. The RDL stores all system content and includes the System Database, the File System and the AR Repository. The

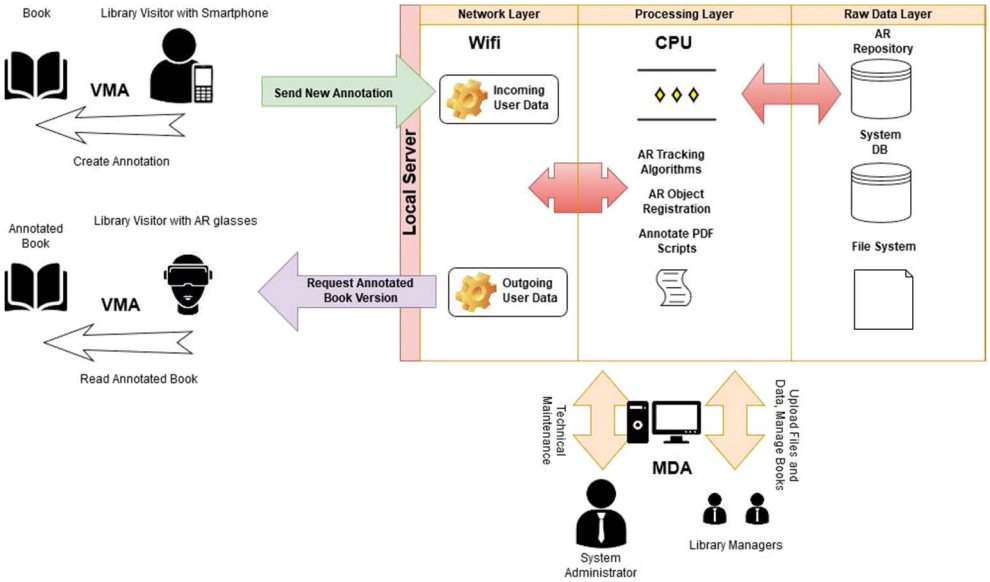

Figure 1. Active Visitor architecture

The RDL communicates directly with PL, while remaining isolated from the end-users. In this way, the system adds a level of security and also RDL implements an extended RBAC scheme.

Management Desktop Application: The MDA is a desktop application that runs on local machines (desktops). Library managers use the MDA to access the LS and upload library and book information to the system (AR Repository, System DB, File System). System administrator uses the MDA to implement the daily maintenance tasks.

Visitor Mobile Application: The VMA is installed in the user's device (smartphone, tablet) and communicates with the LS through the NL. Library visitors can form a social network and engage in digital discussions through the VMA. Furthermore, library visitors and guests read the physical book and use the VMA (Android application) to create and send or receive AR annotations to/from the LS based on their permitted operations. The VMA implements the necessary AR tracking and registration operations.

B. Basic System Operation

PL is the heart of the proposed system as it facilitates the digital book annotation process. Especially, PL gets user submissions from the NL in the form of incoming messages containing information about the book (book page, page row, annotation text) or the discussion messages texts and assigns a unique Annotation ID. Book detachment images are sent directly to the AR Repository and are associated with the Annotation's ID. The PL uses a simple C#.NET program to transform annotation's text (by analyzing the incoming message's annotation text parameter) to the corresponding image in order to be used for the AR registration operation. After the transformation, the PL saves the image in the AR repository and updates the System Database by creating a new record with the image's path and linking it with the associated book record and user. The system uses Acrobat JavaScript to correctly place an annotation on the corresponding PDF file (digital copy of the physical book). When a user request is issued to the system, the PL collects the incoming message, analyzes it, accesses the File System to retrieve the appropriate pdf file based on the message title parameter and creates a new instance of the file assigning a user-related name to it based on the message user ID parameter. Using Acrobat JavaScript the PL automatically opens the pdf file and inserts the user's annotation based on the message text and row parameters. Finally, the PL saves the annotated version of the file. When a new annotation arrives from the user, then the system retrieves the last annotated version of the book. Furthermore, the PL sends outgoing messages to the NL containing information about the book, the book page, the exact page position and the annotation image as well as the discussion text messages. Additionally, the PL communicates with the RDL to get information by the AR Repository, stores the user annotations to a digital copy of the book and updates system database and file system. The AR Repository contains information about all library books (cover pages, pages), book detachments captured from the end-users devices' cameras and transformed annotation images created by the users' annotation texts. Each image path in the repository is linked with a specific record in the System Database (the record contains the full path where the image file is located) in order to be associated with a specific book, book page, book page row and user. Each image is retrieved after user appropriate request. The System Databases contains all system data and the File System contains all system files.

C. Extended Role-Based Access Control Scheme

Users: The system classifies users to several roles/groups with different permission levels. A user can have multiple roles. System users are classified into registered users (administrator, library manager, library visitor) or simple users (guest).

- *Administrator*: The system's super user who supervises every technical procedure, checks system integrity and assigns manager roles to users. Moreover, this user administers the AR repository, system database and file system. Furthermore, the administrator views all AR annotations (public or private), monitors user discussions and deletes users if they don't comply with the library rules.

- *Library Manager (LM)*: User who is a member of the library stuff. LMs update content to the AR repository, the system database and the file system. Moreover, LMs assign the role of library visitor to users that wish to create an account on the system and upload AR annotations. Furthermore, LMs check for user-created AR annotations that violate the library rules, warn or ban users for this purpose and create AR annotations. Finally, LM makes decisions concerning the purchase of a book's digital version.

- *Library Visitor (LV)*: User who has an account on the system. An LV can create, submit and share personal AR annotations while reading a book, view personal and public AR annotations and participate in digital discussions with other concurrent visitors of the library in real-time. An LV can modify only the AR annotations she/he contributes. LVs can purchase an annotated digital version of the book they are reading and they have the capability to ask for a version with their personal AR annotations or a version with public annotations of the same book too.

- *Guest*: A user who reads a book and views public AR annotations associated with the book. Guests cannot purchase an annotated version of the book. Guests can take part in digital discussions with other library concurrent visitors.

Content: System content is information concerning the physical books in the form of text (title, writer, publisher, exact position in the library) and images (book's cover page, inner pages) as well as user text messages during discussions among library visitors. Furthermore, the system stores information concerning the digital versions of the books (physical book id, path in File System, price of the digital copy, number of purchases). AR annotations are stored in the form of both text and images along with their associated users. User messages are also associated with specific users. All content in the form of text is stored on the System Database while the visual content is stored on the AR repository (AR annotations) and the File System.

Permitted Operations: Depending on their role, users have various levels of permission privileges that allow them to perform or not specific operations on the stored content. The basic operations the system supports concerning content access allow a user to create, upload, delete, edit, view, share or purchase content depending on user's role. Moreover, LVs can invite other LVs to a social network, accept or reject invitations and exchange messages.

- *Create*: An LV can create an AR annotation through the VMA by providing the title of the book, the page number and row, the annotation text and a camera-captured image of the book above which the AR annotation will appear.

- *Upload*: LMs can upload library content (like book files) through the MDA. LVs can upload their own AR annotations to the system through the VMA and mark them as public (can be viewed by any user) or personal (can be viewed by the annotation owner only). The user has complete ownership over the annotations she/he uploads and she/he is responsible for that content. If the uploaded content violates library rules then the LV will receive a penalty from the LMs or even a deletion from the system administrator.

- *Edit/Delete*: LVs can edit/delete their personal AR annotations. LMs can edit/delete library content submitted by them or other LMs.

- *View*: LVs can view public or personal AR annotations, while guests can view only public AR annotations while reading a book. LMs can view library content and user AR annotations. LVs can view a list of books they previously read or purchased. LMs can view the borrowing history of a book and the purchasing history of its digital copy. LMs can view book availability and current readers in real-time. LVs can view incoming invitations to join social networks sent by other concurrent LVs that read the same book. Moreover, LVs can view which other concurrent LVs read the same book with them and choose to who they want to send invitations and form a social network.

- *Invite*: LVs can be informed about concurrent LVs that read the same book and choose to invite them in a digital discussion, building a social network.

- *Accept/Reject*: LVs can be notified by another LV to join a digital discussion in real-time and accept or reject the incoming invitation.

- *Exchange messages*: Members of the same social network can exchange text messages.

- *Purchase*: LVs can purchase digital versions of library books with personal and public AR annotations.

V. IMPLEMENTATION

A. Technologies

In order to develop the VMA we use the well-known platforms Unity and Vuforia. More specifically, we use the Unity 2017.3 release combined with Vuforia 7. Implemented applications with Vuforia 7 run on Android 4.4+ mobile devices and optical see-through digital eyewear, the main devices that will be used in a future library installation. Vuforia 7 supports the OpenGL ES 3.x Graphics API for Android and the DirectX11 on Windows 10. The MDA is developed through Microsoft Visual Studio 2017 in .NET 4.7 framework. Windows 10 is the current development environment which hosts the Unity 2017.3 and Visual Studio

2017 installations. The system implementation demands the operation of a local central server operating on Windows Server 2016, which should have IIS 10 enabled. Furthermore, the IIS Database Manager is used to manage system databases.

B. *Services and Usage Scenarios*

Users access system services through different modules based on their role: LVs and Guests through the VMA and LMs through the MDA.

AR Services

Annotation creation: When an LV decides to create a new annotation, she/he activates the VMA on her/his mobile device and navigates to the "Annotation Creation" screen (Fig. 3) where the user enters the book title, the book page, the page row, the annotation text and the characterization of the annotation as personal or public. Furthermore, the user should take a close picture of the exact location in the printed book page where she/he wants the AR annotation to appear. The picture should be as clear as possible in order to be usable by the AR tracking service.


```
{
"annotation": [
      {
    "user_id": "189",
    "book_title": "Zorba The Greek" ,
    "book_page": "1",
    "page_row": "32",
    "annotation_text": "The Konstantis character is the book narrator.",
    "public_annotation": "No",
    "detachment": {
      "filename": "28042018_1.jpg",
      "chunkId": 1,
      "chunkLength": 62535,
      "fileLength": 62535
        }
    }
  ]
}
```


Fig. 2. Example of a JSON outgoing message with user-created annotation

When information is entered, the user clicks on the "CREATE ANNOTATION" button and the annotation body along with the user-captured picture is sent to the LS in the form of a JSON outgoing message (Fig. 2).

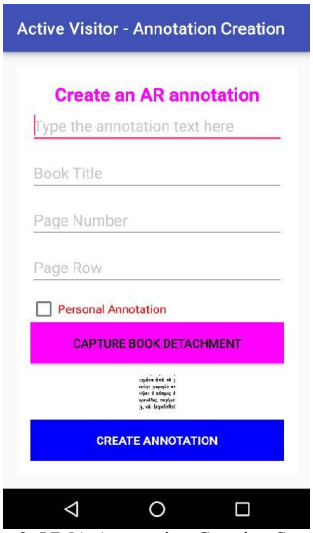

Fig. 3. VMA Annotation Creation Screen

AR tracking & registration: The VMA uses a built-in AR tracking operation packaged in Vuforia 7, the platform in which the VMA is implemented. In particular, the system uses the image (book detachment) that the user captured during the annotation creation as a target for the AR tracking service. When the user focuses her/his mobile device's camera on the book excerpt, the VMA uses the user-created image to track the location that the AR element (annotation) will be registered. The VMA achieves the image target tracking by analyzing the contrast based features of the target image that are visible to camera. More specifically, image targets are detected based on natural features (book letters) that are extracted from the target image and then compared at run time with letters visible in the live camera image. It is very important for the success of the AR tracking service, the clarity of the image target when the annotation is created. If the target image is not focused well in the camera view, the tracking could fail. Lighting conditions are not very important for the AR tracking service since the process happens in an indoor location (library) with uniform lighting. After the successful tracking, the VMA extracts the annotation text tied to that image target and registers the annotation to the right position. The registered element is a modal window that hosts the annotation text embedded in the camera view over the book phrase that the user focuses on (Fig. 4).

Book annotation viewing: Users (LVs, Guests) can view AR annotations through the VMA while reading a book. Annotations appear as rectangular modal windows embedded inside the camera view of the user's mobile device to the corresponding location (page row). Personal annotations appear with a red frame while public ones appear with a green frame (Fig. 4).

Core Services

Account management: The system allows users to create accounts and become LVs. The procedure is monitored by the LMs who assign roles and permissions to registered users. LVs are allowed to update their personal information,

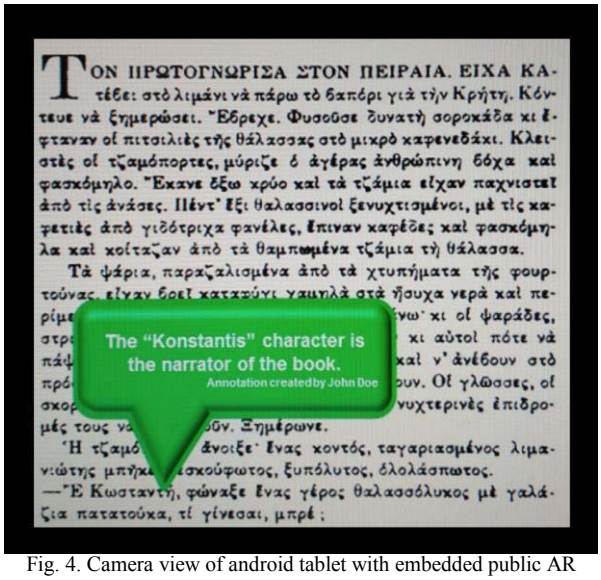

Fig. 4. Camera view of android tablet with embedded public AR annotation

History viewing: LVs can view a list with the books they have previously read, during past library visits. Moreover, LVs view a list of book digital copies they have purchased from the library. LMs update account permission rights in order to keep up with the library policy.

Library book content management: LMs are responsible to register all the library books on the system. For each book, the LMs submit book-related information like the title, description, keywords, writer, publisher, publication date, copyrights, library section, shelf and paths to the associated files in the File System (digital version of the book, annotated or not) and the AR Repository (images of the cover page, inner pages and user-created AR annotations). Furthermore, the LMs update the borrowing history of each book and the information related to each digital book copy purchased by users. Library Managers can view in real-time the users who read a book and a book's current availability.

Fig. 5. Send Invitation Screen

Fig. 6. Receive Invitation Screen

Annotation sending: In order to send a newly created AR annotation to the LS, an LV connects to the library's wireless network through her/his mobile device (smartphones, tablets, wearables). After annotation creation, the VMA prompts the user to send the annotation text to the server. Following user approval, the VMA sends a json message with the annotation text, book title, book page, page row and annotation origin (personal, public) to the LS for processing along with the picture of the book detachment where the annotation will be placed. Annotations are processed by the system in batches in order to decrease the system response times.

Personalized book digital version purchasing: LVs can purchase the annotated digital version of a book with personal and/or public annotations. Purchasing policy is defined by the imposed copyright restrictions of the book and its electronic version.

Social Services

Invite member service: An LV can view which concurrent LVs read the same book during their library visit, through the appropriate VMA screen (Fig. 5). The LV can send an invitation to one or more LVs inviting them in forming a social network and initiate a discussion about the book.

Accept/Reject invitation service: When an LV receives a discussion invitation by a concurrent LV to her/his mobile device, she/he can choose to accept or reject the invitation. If the user accepts the invitation, she/he becomes a part of a social network focusing on a specific library book (Fig. 6).

Discussion service: LVs can exchange text messages with other members of the same social network, through the VMA's corresponding screen (Fig. 7). Each message is associated with a user and it is stored in the System Database. An LV can retrieve any discussion that she/he has participated through the account management screen of the VMA.

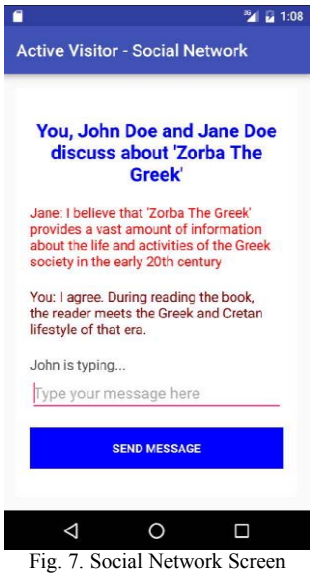

Fig. 7. Social Network Screen

VI. EVALUATION

We performed a first evaluation of the proposed system by distributing questionnaires to librarians and library visitors and measuring users' opinions towards specific system services characteristics (ease of use, usefulness, importance, attractiveness, user engagement, exploitation capabilities, cost and space requirements feasibility). At first we divided the interviewees in two groups (librarians and visitors). The librarians group consisted of 19 professional librarians of various experience levels and age groups that work in public or university libraries. The visitors group consisted of 27 individuals of various age groups that visit a library more than once a year. In each group, we explained in details the nature of the proposed system and the main services offering to its users. Afterwards, we presented a case study of the system using a physical book and creating an AR annotation on the book with the VMA. Moreover, a user started a discussion with another user about the book via exchanging text messages. At the end of the demonstration, we initiated a discussion with the members of each group and answered to

their inquiries. Finally, we distributed questionnaires (different for each group) and allowed each individual to answer questions for 30 minutes. We chose to use dichotomous questionnaires where users express their agreement or disagreement to a series of statements because our goal was to capture their first spontaneous impression after a first contact with the system. Librarians' evaluation results are shown in Tab. I and visitors' results are shown in Tab. II.

TABLE I. LIBRARIANS OPINIONS TOWARDS PROPOSED SYSTEM CHARACTERISTICS

Characteristic	User Agreement Percentage
AR services – Ease of Use	96%
AR services - Usefulness	95%
AR services - Importance	68%
AR services – Visitor Attractiveness	90%
AR services – Visitor Engagement	71%
AR services - Exploitation	14%
AR services – Space Requirements Feasibility	82%
AR services – Cost Requirements Feasibility	0%

The main purpose of the librarian questionnaire was to measure how experienced professionals feel about the adoption of such non-traditional services, like the proposed system's AR services, from a library. Librarians answered emphatically positive that they would easily use the service and the system in general and they would not have a problem in guiding visitors to use system services (96%). 95% of the librarians pointed out that the system's AR service would be useful to a modern library. More than 2 out of 3 librarians (68%) answered that they found the adoption of such an AR service important for their library. 90% of the librarians responded that offering such an AR service would increase the number of visitors in the library and 71% agreed that the presence of such a service would prolong the time visitors spend within a library. Librarians kept a really skeptical position (14%) towards the direction of exploiting the AR service in order to generate revenue for the library because they do not believe that visitors would pay for any services. 82% of the librarians agreed that the system could be supported in terms of space requirements by their facilities. All professionals agreed that their institute would not have the money to purchase such a system even though we did not present the expected cost of the proposed system.

An overview of the questionnaire results reveals the potential that the proposed AR service could bring to a library according to librarians in terms of visitor attractiveness and engagement. Even though librarians cannot envision, at this point, how a library could exploit an AR service they admit that the adoption of such services is important and useful. The professionals highlight their agony about the cost that such a system could bare since libraries do not have large budgets, providing us with an undisputed technical requirement, low installation and operational cost.

TABLE II. VISITORS' OPINIONS TOWARDS PROPOSED SYSTEM CHARACTERISTICS

Characteristic	User Agreement Percentage
AR services – Ease of Use	88.5%
AR services - Usefulness	89.9%
AR services – Visitor Attractiveness	93.5%
AR services – Visitor Engagement	79%
Annotation service and personalized digital copy - Purchasing	39%
AR services – Equipment Existence	96%
Personalized Digital copy usefulness	93%
Social services - dissemination	65%
Social services - sharing	87%
Social services - discussion	56%

The main purpose of the library visitors' questionnaire was to measure how visitors evaluate the proposed system's AR and social services. Visitors agreed that the proposed AR service would be easy to use (88.5%) and very useful for their professional activities (89.9%). An excellent 93.5% responded that the existence of the proposed AR service would play a key role into visiting a library, while 79% of users agreed that the usage of such a service would engage them for longer periods of time. A satisfying 39% answered that they would pay to use the AR service or purchase an annotated digital copy of the book they read during their visit. The capability to create and obtain a personalized annotated digital copy of a book was appreciated by almost all visitors (93%). Furthermore, 96% of the visitors responded that they possessed a camera-ready smartphone so they would be able to use the proposed service without additional cost. 65% of the visitors agreed that they would be eager to announce their presence to a library that offers AR services to their peers via social media. The great majority of visitors (87%) answered that they would be willing to create public AR annotations and share them with other visitors. 56% of the visitors responded that they would engage in digital discussions with concurrent visitors about a book they were reading.

Overall, the above results may suggest that the proposed system fulfills its purpose to offer interesting, useful, attractive, easy to use and engaging services for library visitors. Furthermore, a significant number of potential visitors answered that they were willing to pay for those services. Library visitors were less reluctant to pay for library services with the aforementioned characteristics addressing the fear expressed by librarians that users would not pay for such services. Moreover, visitors' answers suggest that a modern system is essential to offer social networking services to its users. A modern system for libraries should provide the opportunity to each user to contribute self-generating digital content associated with her/his activities during a library visit and sharing it with other individuals.

VII. CONCLUSIONS

Offering interesting, useful, user-friendly and engaging services to library visitors is a bet that every library should win. Libraries should be open-minded to adopt new technologies like AR and adapt them to the special characteristics a library environment demonstrates. Moreover, a modern library digital system should incorporate social networking capabilities which will disseminate effectively the library's services to the broad public through the social activities of the library visitors. We propose Active Visitor, a system that provides interactive AR and social services to library visitors. In particular, the proposed system allows users to use their mobile devices and create AR annotations while reading a library book. Users can view their personal and public AR annotations above the book phrase where they created the annotation as digital elements embedded in the camera view of their mobile device. Furthermore, each annotation is embedded in a digital copy of the book they are reading, automatically. Users have the capability to purchase the personalized digital copy. Active Visitor allows users to share their annotations with concurrent library visitors and engage in digital discussions with them with the exchange of text messages forming small social networks in real-time. System evaluation results revealed that the system satisfies both the audiences of potential library visitors and experienced librarians. Moreover, the system offers the opportunity to libraries to generate additional sources of revenue with costs adjustable to their limited budgets. For our next steps, we will try to fully automate the procedure of annotation creation and viewing. Moreover, we came in contact with a library in order to install and test the proposed system in real conditions. Furthermore, we seek to use and evaluate the proposed system through AR glasses. As wearable AR technology evolves every day, AR glasses are expected to further revolutionize AR technology and lead to mass usability.

REFERENCES

[1] K. Varnum, The top technologies every librarian needs to know: A LITA guide. ALA Tech Source, 2014.

[2] K. Varnum, "Predicting the Future: Library Technologies to Keep in Mind", International Information & Library Review, vol. 49, pp. 201-206, September 2017.

[3] R. Azuma, "Making Augmented Reality a Reality", in Imaging and Applied Optics 2017 (3D, AIO, COSI, IS, MATH, pcAOP), pp. JTuF1F.1, June 2017.

[4] R. Azuma, "A Survey of Augmented Reality", Teleoperators and Virtual Environments, vol. 6, pp. 355 – 385, August 1997.

[5] S. Montgomery, and J. Miller, "The Third Place: The Library as Collaborative and Community Space in a Time of Fiscal Restraint", College & Undergraduate Libraries, vol. 18, pp. 228 – 238, June 2011.

[6] C. Carpenter, "Transforming the Georgia Tech Architecture Library into a Social Space", J. of The Art Libraries Society of North America, vol. 30, pp. 79 – 83, Spring 2011.

[7] S. Graubard, and P. LeClerc, Books, Bricks & Bytes - Libraries in the twenty-first century. Routledge Taylor & Francis, London and New York, 2017.

[8] S. M. Esposo Betan, and J. Santos, "Advantages and Challenges of Using Augmented Reality for Library Orientations in an Academic/Research Library Setting", in Proc. Of the 38th Annual IATUL Conference, June 2017.

[9] N. Green, "On the Move: Technology, Mobility, and the Mediation of Social Time and Space", The Information Socviety an International Journal, vol. 18, pp. 281 – 292, 2002.

[10] B. Wellman, A. Haase, J. Witte, and K. Hampton, "Does the Internet Increase, Decrease, or Supplement Social Capital? Social Networks, Participation, and Community Commitment", American Behavioral Scientist, vol. 45, pp. 436 – 455, November 2001.

[11] C. Cheung, P.-Y. Chiu, and M. Lee, "Online social networks: Why do students use facebook?", Computers in Human Behavior, vol. 27, pp. 1337 – 1343, July 2011.

[12] B. Massis, "Using virtual and augmented reality in the library", New Library World, vol. 116, pp. 796 – 799, 2015.

[13] HP Reveal, "HP Reveal", *hpreveal.com*, 2018. [Online]. Available: https://www.hpreveal.com/. [Accessed: Apr. 20, 2018].

[14] EON Reality Inc., "EON Reality", *eonreality.com*, 2018. [Online]. Available: https://www.eonreality.com/. [Accessed: Apr. 20, 2018].

[15] Layar, "Layar", *layar.com*, 2018. [Online]. Available: https://www.layar.com/. [Accessed: Apr. 20, 2018].

[16] M. Kljun, K.C. Pucihar, and P. Coulton, "User Engagement Continuum: Art Engagement and Exploration with Augmented Reality", in Augmented Reality Art, V. Geroimenko, Ed. Springer Series on Cultural Computing, Springer, Cham, 2018, pp. 329 – 342.

[17] K. Barry, and C. Street, "Immersive Indiana: Constructing an Augmented Reality in Columbus", in *Immersive Learning Research Network, iLRN 2017*, *Coimbra, Portugal, June 26 – 29, 2017*, D. Beck et al., Eds. Communications in Computer and Information Science, vol. 725. Springer, Cham, 2017.

[18] A. Dhir, and M. Al-kahtani, "A Case Study on User Experience (UX) Evaluation of Mobile Augmented Reality Prototypes", J. of Universal Computer Science, vol. 19, pp. 1175 – 1196, January 2013.

[19] J. F. Hahn, B. Ryckman, and M. Lux, "Topic Space: Rapid Prototyping a Mobile Augmented Reality Recommendation App", *Code4Lib Journal*, vol. 30, October 2015. [Online]. Available: https://www.ideals.illinois.edu/handle/2142/88351. [Accessed: Mar. 05, 2018].

[20] L. Vidlund, and C. Petersson, "Use marketing as a strategy for skill development Tablets, QR, AR – our journey from printed book collections to a social place", in *Qualitative and Quantitative Methods for Libraries QQML 2014*, *vol. 3, pp. 583 – 589*, I*stanbul, Turkey, May 27 – 30, 2014*.

[21] D. Chen, S. Tsai, C.-H. Hsu, J. Pal Singh, and B. Girod, "Mobile augmented reality for books on a shelf", in *Proc. of the 2011 IEEE International Conference on Multimedia and Expo, ICME 2011, July 11-15, 2011, Barcelona, Catalonia, Spain*.

[22] D. Koukopoulos, and G. Styliaras, "Security in collaborative multimedia web-based art projects," J. of Multimedia, vol. 5, no. 5, pp. 404-416, October 2010.

[23] D. Koukopoulos, D. Tsolis, and G. Heliades, "Ionian Music Archive: application of digitization, management and dissemination technologies for musical cultural heritage," in *Proc. of 5th Int. Conf. on Information, Intelligence, Systems and Applications, IISA 14, Chania, Greece, July 7 – 9 2014, pp. 239-244, IEEE*.

[24] D. Ferraiolo, and R. Kuhn, "Role-Based Access Control", in *15th National Computer Security Conference*, *Baltimore, USA, Oct. 16 – 19 1992*, *pp. 554–563*.