2017

STAK – Serendipitous tool for augmenting knowledge: A conceptual tool for bridging digital and physical resources

Kim Martin
Western University

Brian Greenspan
Carleton University

Anabel Quan-Haase
The University of Western Ontario, aquan@uwo.ca

STAK – Serendipitous tool for augmenting knowledge: A conceptual tool for bridging digital and physical resources

Kim Martin, University of Guelph: kmarti20@uoguelph.ca

Brian Greenspan, Carleton University: brian.greenspan@carleton.ca

Anabel Quan-Haase, University of Western Ontario: aquan@uwo.ca

Peer-reviewed by: Jon Bath, University of Saskatchewan; Mia Ridge, British Library.

Accepting Editors: Susan Brown, University of Guelph; Padmini Ray Murray, Srishti Institute of Art, Design & Technology; and Jon Saklofske, Acadia University.

Abstract / Résumé

Humanities scholars have long claimed the importance of browsing in the library stacks as part of their research process. The digitization practices of libraries and archives, while meant to assist with preservation and access, make the physical browsing experience impossible. While there have been various attempts to recreate this experience online, none as yet has created a digital tool which users can interact with as they move through the physical material in the library. This paper aims to introduce the concept of the Serendipitous Tool for Augmenting Knowledge (STAK), a geolocative app that allows users to access material complementary to what they are looking at on library shelves. The authors outline the research behind STAK, the potential for locative media and augmented reality in libraries, and the design requirements for STAK. Finally, they outline two elements of serendipity that they hope to emulate in STAK: Noticing, and Capture and Recall. By enhancing the physical collection with digital information, STAK aims to bring scholars the best of both worlds, and to encourage them to return to the physical library to explore, learn, and browse.

Depuis longtemps, les chercheurs des sciences humaines soulignent l'importance dans leur processus de recherche de parcourir des ouvrages dans les rayons des bibliothèques. Bien que les pratiques de numérisation des bibliothèques et des archives aient pour objet d'aider la préservation et l'accès, elles rendent aussi impossible l'expérience de la consultation physique sur place. Il y a bien eu diverses tentatives pour recréer cette expérience en ligne, mais aucune n'a jusqu'à présent créé un outil numérique avec lequel les usagers peuvent interagir alors qu'ils consultent physiquement la documentation dans la bibliothèque. Cet article vise à introduire le concept de Serendipitous Tool for Augmenting Knowledge (STAK) (Outil fortuit pour l'enrichissement de la connaissance), une application géo-locative qui permet aux usagers d'avoir accès à une documentation complémentaire à celle qu'ils recherchent dans les rayons de la bibliothèque. Les auteurs présentent la recherche motivant STAK, le potentiel des médias locatifs et de la réalité enrichie dans les bibliothèques, et les exigences de la conception de STAK. Enfin, ils soulignent deux éléments d'heureux hasard qu'ils espèrent imiter dans STAK: Constater, et Saisir et Rappeler. En optimisant la collection physique au moyen de l'information numérique, STAK vise à apporter aux chercheurs le meilleur des deux

mondes, et à les encourager à retourner dans la bibliothèque physique pour explorer, apprendre et parcourir les ouvrages.

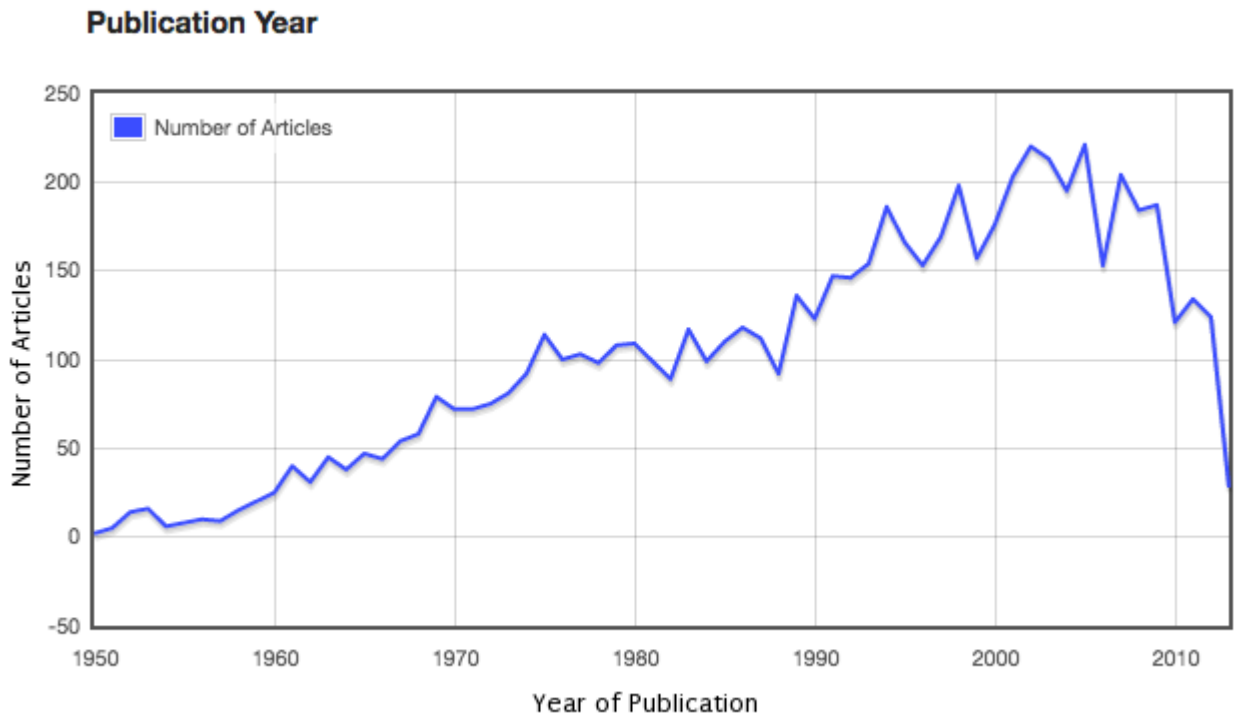
Keywords / Mots clés

Serendipity; libraries; academic libraries; locative media; augmented reality; information seeking

Introduction

Humanities scholars often describe the act of stumbling unexpectedly across useful material during their research process as *serendipity*. Scholars from law, history, and other humanities fields have commented on the importance of serendipity, or the chance encounter with information, to their research (Fyfe 2015; Hoeflich 2007; Martin and Quan-Haase 2013; Martin and Quan-Haase 2016; McClellan III 2005). Despite the challenges associated with studying this elusive concept that is difficult to elicit in a controlled environment, the number of studies focusing on serendipity has increased at a steady pace since the 1950s, reaching a peak in the early 2000s (see Figure 1). There have been multiple attempts at modeling the serendipitous experience (Makri and Blandford 2012a; Rubin, Burkell, and Quan-Haase 2011), the chance encounter with information (McCay-Peet, Toms, and Kelloway 2015), and information encountering in general (Erdelez 1999; Erdelez 2004).

*Figure 1: Instances of the word "serendipity" in titles of journal articles in the JStor database. Taken from http://dfr.jstor.org/ August, 2016. *More recent articles may not as yet be indexed.*



This paper introduces the Serendipitous Tool for Augmenting Knowledge (STAK), a digital tool that aims to explore the connections between a user's experience in the physical library and those in the digital. As digital resources, and in particular Google products, increase in popularity across all disciplines (Chen 2010; Georgas 2015; Howland et al. 2009), including the humanities (Kemman, Kleppe, and Scagliola, 2014), it becomes increasingly important to understand the continued value and relevance of the physical library, and how to bridge the gap between physical, material resources and digital archives. After a brief discussion of scholars' experiences with serendipity in physical and digital environments, we outline the results from a series of tests to determine how users (in this case graduate students) explore the physical library when asked to complete a search task. The results will serve to create a model of search and exploration that can guide the design of future tools for connecting physical and digital resources. Secondly, we introduce the literature on the use of locative media and location-based services in libraries, and identify a set of requirements for our proposed model for the STAK interface, detailing the potential for this tool to

encourage serendipity. Finally, we outline the two main elements of serendipity that we hope to emulate in STAK: *Noticing* (Rubin, Burkell, and Quan-Haase 2011) and *Capture and recall* (Erdelez 2004), before concluding with plans for the development of a working prototype of this locative media tool.

Physical and digital environments

Scholarly interest in serendipity and how scholars experience it has only intensified with the increasing centrality of digital scholarly resources in all fields of humanistic inquiry (Martin and Quan-Haase 2016). Humanities scholars now make use of a wide range of digital technologies to expedite, amplify, and support their scholarly practice (Schaffner and Erway 2014; Toms and O'Brien 2008). As Susan Brown (2011) states, "The humanities are being swiftly retooled by digital media and methods. More and more material from the past is being digitized, and the record of our current culture is increasingly 'born digital' whether we are talking about politics, media and communications, fine arts and letters, or the scholarly record" (203). The digitization of library resources has altered how humanities scholars look for, make use of, and interact with sources, raising new questions about the nature of serendipity across physical and digital environments, and whether this experience can be fostered through design (Martin and Quan-Haase 2013). In the field of information studies, researchers have looked at blogs (Rubin, Burkell, and Quan-Haase 2011), resource discovery tools (Race 2012), web searching (Erdelez 2004), and networks of information acquisition (Quan-Haase, Martin, and McCay-Peet 2015; Williamson 1998) in order to understand the phenomenon of the chance encounter. While these efforts have provided important insights into how serendipity occurs in different digital contexts, it remains unclear whether serendipitous encounters are experienced the same way in digital and physical contexts, and whether scholars respond with similar search strategies in these differing environments.

Many humanities scholars now choose to interact with texts online, either through a general search engine or via a library website (Toms and O'Brien 2008), with Google Scholar in particular playing a central role (Kemman, Kleppe, and Scagliola 2014). The prolific use of digital information environments by humanities scholars has dramatically widened the divide between physical and digital documents. The question emerges as to whether or not the experience of discovering texts serendipitously will be lost as humanities scholars turn increasingly to digital environments and search engines to seek information through direct queries. Although serendipity is widely recognized by humanities scholars as taking place in the physical library, the experience is in fact finding its way into the digital environment, albeit in altered form (McCay-Peet, 2013). In this paper we investigate how to create greater integration between resources available in digital and physical information environments, while enhancing scholars' experience of serendipity and engagement.

Observing users as they navigate the library

More and more digital resources become available every day, but there remains a massive store of information resources on analog media (including print, film, microfilm, and videocassette) that will not be digitized for years to come. This situation has led humanities scholars, and historians in particular, to be concerned that this older analog material will never make it into academic studies, as younger scholars tend to focus on what is easily accessible in digital formats (Borgman 2009; Martin and Quan-Haase 2013). Despite these concerns, even the youngest scholars working in digital humanities do recognize the value of physical resources, and will likely require access to analog holdings at some point in their research.

In light of these conflicting views on printed and physical material, we conducted user tests to study how scholars use the library stacks, and to help us determine what kind of browsing tool might best assist them. The twelve participants we recruited were all graduate students enrolled in Digital Humanities courses at Carleton University. Each individual participant was assigned two search tasks. Both tasks were aimed at creating real-case scenarios that would elicit complex search behaviors. The first task is exploratory in nature and elicits browsing and looking, while the second is task-oriented and elicits more specific problem-oriented information behaviors.

1. Explore the library for 5 books that are relevant to you in terms of previous courses, life experience, interests, hobbies, problems, concerns, or information needs; and
2. Pretend you are writing an essay on the Digital Humanities. Search for items about recent trends in DH, the history of DH, and humanistic computing.

The participants completed Task 1 before moving on to Task 2 in the same test session. Each session took approximately 45 minutes. We attached a Contour 2+ mobile camera with a Global Positioning System (GPS) to the participants' heads to track their progress, which generally took about 20 minutes for each search task. A team of three researchers followed the participants through the library to observe and document their progress. Participants were encouraged to speak aloud during the experiment; their monologues were captured on a portable digital audio recorder, and later reviewed with each of them in structured post-task interviews. In addition, the research team took digital photos documenting the items retrieved from the stacks by each participant.

Although our tests are ongoing, we are already finding consistent responses common to our test participants:

1. **Disorientation**: Regardless of their personal familiarity with the library, all participants reported some degree of disorientation while navigating the stacks.
2. **Dissatisfaction**: They also discussed being dissatisfied with existing library guides, such as online catalogs and maps.
3. **Digital Search Strategies**: When beginning a search, participants typically used the online catalog to find call numbers for specific items in the stacks, but only as a lead into broad subject areas. Once participants located the general subject area in the stacks, they used a combination of title, author, and cover scanning to locate materials of potential relevance.
4. **Discovery**: Even though we gave our users specific search tasks, and compensated them for their time, in the majority of cases, participants discovered one text of relevance to a project *other than their primary search task*. Usually, they found items relevant to either their thesis or a course paper they were currently writing. Even as they apologized for (seemingly) breaking experimental protocol, these subjects insisted on taking the researchers along with them during their serendipitous finds.

It should be stressed that participants demonstrated wide variability in both their search strategies and their personal comfort with the physical library. Still, our tests suggest overall that even relatively young scholars in the humanities continue to rely on printed information, as well as the library's physical layout, organization, and proximity of resources, to structure their research. They not only distrusted the thoroughness of online catalogues, but also frequently reported positive experiences of serendipitous discovery in the physical stacks. Participant 7, for example, stated the following in her post-task survey:

It's kinda fun because walking through the stacks, certain titles catch your attention, so you say Oh, pause, keep looking, and end up somewhere completely different. In other parts of the library, I do find it's useful to see what's there, because I don't know where anything else is. Sometimes you end up finding things you really didn't expect. (Participant 7)

Our results indicate that it may be possible to elicit serendipitous experiences through a designed task, a goal that previous research has suggested to be unlikely (Erdelez 2004).

Locative media and augmented reality systems for libraries

One reason that serendipitous experiences are different for digital and physical library holdings is that the former tend increasingly to be online and distributed, while the latter are always confined to specific geospatial locations. Digital resources are usually located and browsed through a search engine or other index, which may therefore be involved in the creation of a serendipitous experience. By contrast,

analog resources support direct browsing of the physical record, so that an item's material characteristics (such as its size, appearance, or location on the shelves) contribute to the likelihood of it creating a serendipitous experience. Our aim is to design the prototype STAK browser to elicit serendipitous finds within physical libraries by drawing upon the online cloud of data that surrounds analog holdings. To that end, STAK will integrate tools for searching online library indices and locating physical items simultaneously.

Systems to aid in the location of physical records not only involve radically different hardware and software design than systems for the search and retrieval of online information items, but are also much less developed. Early research into the potential of locative RFID systems for libraries largely restricted their use to circulation and security functions, including automated check-in and check-out, anti-theft detection, and rapid inventory (Repanovici et al. 2009; Shahid 2005). Innovative systems such as ShelvAR (2013) even use Augmented Reality (AR), or sophisticated context-specific visual overlays, to help librarians find misplaced items while shelf reading. System librarians have long speculated on the broader integration of such systems with research services in ways that go beyond the usual surveillance and self-service tasks, such as interactive library maps and guides (Huang, Chang, and Chuang 2007; Reilly et al. 2006; Satpathy and Mathew 2006), but only recently have real attempts been made to link a user's location with direct, integrated access to library holdings for real-time contextual and situational data retrieval.

As AR apps for mobile devices, such as FourSquare, Yelp Monocle, Layar, and Pokémon Go have become increasingly commonplace, researchers have brought renewed attention to the potential of AR systems for providing enhanced contextual information in cultural settings, including memorial sites, museums, and libraries. The integration of AR into library settings is often still presented as a speculative practice. Hahn advances several speculative use cases for AR in library settings, including graphical overlays to assist in library navigation, and a mobile app for students that would visually overlay digital content onto the physical stacks, providing circulation information about specific volumes, or recommending related titles (Hahn 2012). Denton frames his vision of library AR systems within a science-fiction narrative describing how these technologies might appear in 2017 (Denton 2014). In fact, dedicated library apps are no longer just vaporware: there exist a handful of creative AR applications developed for libraries at the experimental stage, including the AR game GARLIS developed by Wang et al. to teach library skills to elementary students (Wang et al. 2013). Noting the lack of context-aware AR library tools, Shatte, Holdsworth, and Lee developed Libagent, a promising experimental agent-based mobile library management system designed to improve the user's experience of the stack by leveraging contextual information about the actual status of the physical shelf, such as which books are missing or on loan at any given time (Shatte, Holdsworth and Lee 2014).

Tools like ShelvAR, GARLIS, and Libagent were developed to help librarians or users with specific sorting, search, and retrieval tasks, and so depend upon complex optical edge recognition systems, on fiducials or physical markers such as QR codes, or on digital compasses and accelerometers to identify the user's location in the library with fine-grained precision (Shatte, Holdsworth, and Lee 2014). Development of these systems proceeds slowly because they depend upon determining the user's indoor location with precision in order to assist with focused and directed search tasks. By contrast, our proposed STAK tool is designed to augment the user's search by highlighting loosely related and unforeseen resources of possible interest. STAK will therefore not only tolerate a degree of geolocational inaccuracy, but may even benefit from the fuzziness it introduces to the search scenario, as our user tests suggest that such relaxed navigational awareness may help to create the conditions for serendipitous discovery. It is important to note that we are not proposing a substitute for keyword-based retrieval systems; rather, our proposed model provides users with an alternative to existing search functionality, one that draws on inferences about the user's scholarly interests and geospatial context to help find information at the boundaries.

STAK requirements

We propose that serendipity can be enabled through the right digital tool. But just how do you operationalize an experience defined by its contextual surroundings, infrequency, and unpredictability? Can we even speak of a serendipity algorithm (Andrew 2014)?

We have identified a series of tool requirements based on our user tests. When completed, our tool will bridge physical and digital information resources in a hybrid browsing environment by offering several affordances to the user. STAK will:

1. **Augment the physical collection with the digital data that surrounds it.** Rather than replace books, journals, and microfilm with databases, we can combine and converge them through a single mobile interface.
2. **Preserve the affective experience of physical browsing by allowing for the tactile and embodied experience with research materials**. Complaints that e-book devices lack the familiar volume and tactility of printed books are common enough to take as an indication that digital resources lack some important physical affordances that have come to shape the reading experience. Mangen's description of this lack typifies the views of many authors: "The reading process and experience of a digital text are greatly affected by the fact that we click and scroll, in contrast to tactilely richer experience when flipping through the pages of a print book. When reading digital texts, our haptic interaction with the text is experienced as taking place at an indeterminate distance from the actual text, whereas when reading print text we are physically and phenomenologically (and literally) in touch with the material substrate of the text itself" (Mangen 2008, 145). The very fact that e-resources can be widely and quickly distributed through networked databases may actually hinder their uptake by researchers who have grown to depend upon more tangible and spatially determinate information resources. Given and Leckie have shown that physical proximity, the accessibility of a book on the shelf, remains the single greatest determinant of which sources researchers cite in their work (Given and Leckie 2003). Moreover, Martin and Quan-Haase found in a controlled study that 15 out of 20 historians tested thought that the tactile element of browsing was an integral part of the serendipitous experience (Martin and Quan-Haase 2013).
3. **Enhance the physical library with the metadata and extant library organization system.** Our tests show that humanities scholars tend to use keywords, subject headings, and other metadata as currently represented by library catalogues merely as a seed for broader physical searches in the stacks. Given that scholars credit internal organizational systems of libraries as a factor in their serendipitous encounters, we anticipate that metadata can provide a basis for the discovery of serendipitous links.
4. **Support users' recall through the spatial experience of information.** Most readers will be familiar with the phenomenon that Harpold calls *historiation,* the "Here, here, here" of the page that triggers a reader's textual memory through spatial and volumetric cues (Harpold 2009). Our user tests show that researchers rely upon such spatial and tactile cues to guide their research, and will visit the stacks in order to elicit them.
5. **Use the physical library environment to encourage the kinds of distractions and unexpected links that create serendipitous experiences**. Booksellers know that people tend to notice books placed at eye level. Although our test subjects frequently grabbed the biggest or brightest book on the shelf without any other justification, in almost every case it was the resources they chose in this way that led them to serendipitous experiences.

The STAK interface and architecture

We are exploring design parameters for the proposed STAK tool with the five aforementioned requirements in mind. Our analysis of library search behaviors suggests that both printed books and digital resources are more useful when linked together. To that end, our goal is to provide a web-based tool for mobile devices that augments the user's experience of browsing physical collections by creating opportunities for the serendipitous discovery of information resources. Our current approach is to augment physical holdings with

related resources linked via keyword, subject heading, author, and title (that is, readily available metadata), including other books and print journals, as well as digital resources available through the library portal, such as e-books, e-journals, and other online assets.

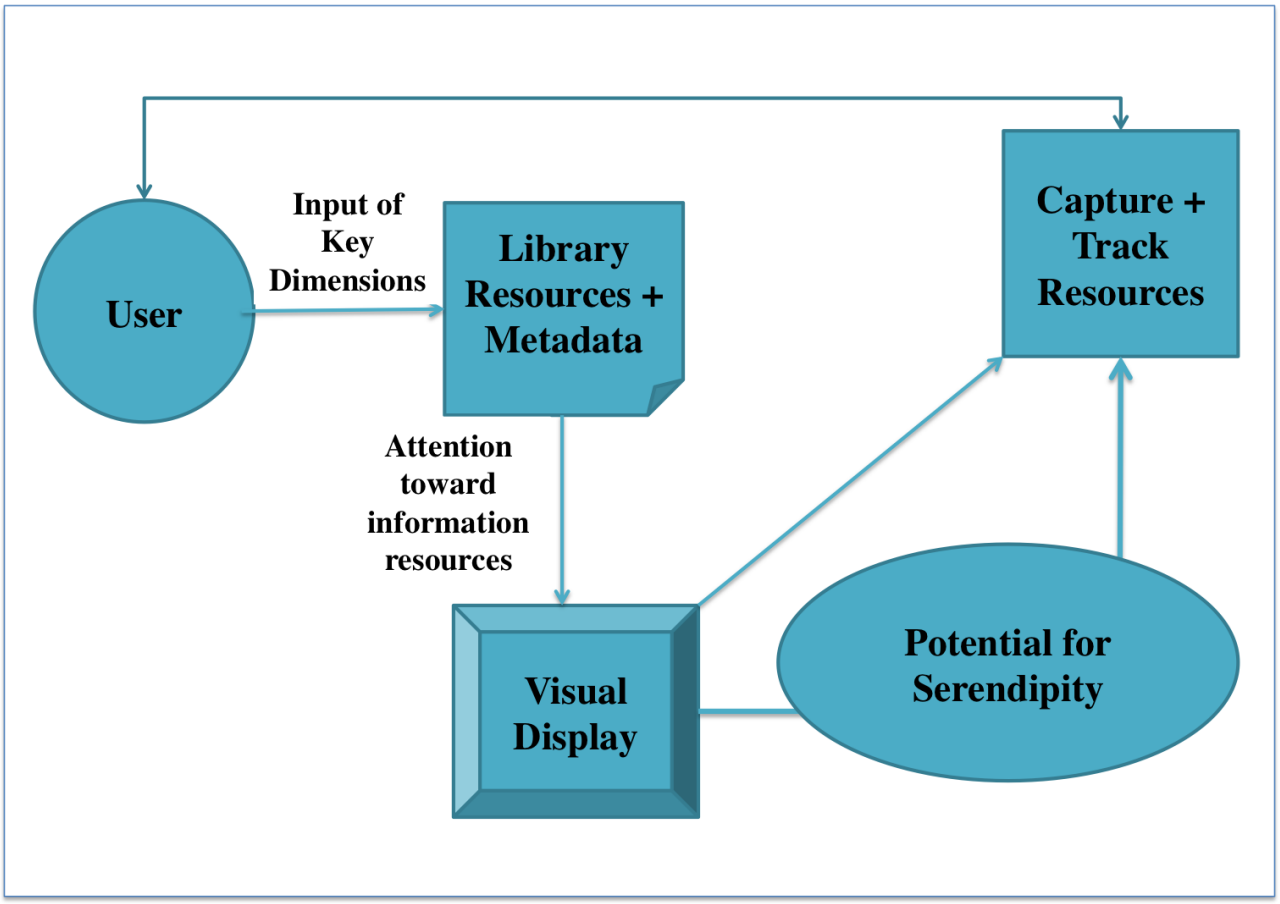
There are four (4) main components to the proposed tool:

1. A dynamic user model based on the user's evolving research interests.
2. An algorithm to bridge this user model with library metadata.
3. Audio and visual cues to draw potential opportunities for serendipity to the user's attention.
4. A tool that allows users to capture items of interest and track their location as they move throughout the physical library.

Unlike recommender systems that rely on consumer statistics ("People who liked this title also liked . . ."), our proposed STAK tool will cater its results to the user's personal research profile, preferences, and habits. STAK will begin by asking new users to input keywords, headings, favorite authors and books, or similar resources as seeds from which the system will generate a *dynamic user model*. With the user's permission, STAK could also be linked to their library account, or to extant citation collections from open source tools such as Zotero (https://www.zotero.org/), so that the knowledge about the user grows as they continue to check items out of the library, or build their citation lists. This user model, combined with our augmented search algorithms, will allow STAK to return items of potential significance to the individual library user's attention. It will infer the nature and subject of the user's current search task by identifying his or her location in the stacks, and use readily available metadata (e.g. keyword, subject heading, author, and title) to automatically draw reviews or related works of potential interest from digital resources available through the library portal, such as e-books, e-journals, and other online assets (See Figure 2).

At the same time, STAK will identify physical items on nearby shelves of potential interest to the user, and draw attention to them using audio and visual cues. If a recommended resource catches the eye of the user, STAK will allow them to either find its location, or capture its placeholder and save it for later. Importantly, the information that the user saves for later is then re-introduced in later browsing experiences to remind them of the link they previously made.

Figure 2: Model for the potential for serendipity in STAK



The general architecture and interface design of STAK is based on StoryTrek, a web-based authoring tool designed at Carleton University's Hyperlab for the rapid prototyping and development of locative media. Story Trek allows authors with just a few minutes of training to layer rich multimedia assets onto Google maps, creating extensive and connected web-based spatial stories that respond in real time to the vector and style of the user's movement through real space. For instance, we used StoryTrek to build a mobile location-based game for children based on museum and archival holdings documenting the story of the Rideau Canal, a UNESCO World Heritage Site (Greenspan and Whitson 2013). This game turns the archives inside out, mapping them back onto the local landscape.

STAK will enact this process in reverse, by bringing the world of online data into the library stacks as an aid for locating specific items of interest on the shelf. To that end, we will adapt StoryTrek's spatial algorithms to indoor library and archival settings where GPS does not always work by using a combination of Wi-Fi, RFID tags, and Bluetooth beacons. As a location-aware tool, STAK will sense the user's position in the library and identify likely candidates for serendipitous discovery from among nearby holdings, by matching keywords from a user-generated model of research interests with metadata from the library catalogue. Our goal is not to seed random catalogue searches: serendipity does not arise from mere randomness, but rather from the *prepared mind* of the user: their knowledge base and interests (current and past), and their ability to make links to these interests and the information presented to them by the tool (Burkell, Quan-Haase, and Rubin 2012). At the same time, we recognize the paradox in designing an algorithm to reliably generate serendipity, which is anything but a rational phenomenon. In post-test interviews, our subjects admitted to reaching for volumes of possible interest based not only on their call numbers or titles, but also on their shelf location, size, or even the colour of the binding. Moreover, subjects often indicated their awareness that such methods of selecting resources have less to do with logic than their own, seemingly

impetuous or distracted, acts of noticing. When asked why a particular volume caught her eye, Participant 4 replied:

> The title was in bold print, it was a large book, I think that's why I noticed it, because the book itself was a very vibrant colour. . . . Often I notice the cover of the book before the title itself, and just take it from there. That's why it's funny that the 85 million books [just] like this, the re-covered bland, grey or black books, those are the ones I have a hard time finding because I don't notice them right away.

Merely noticing the volume, however, does not guarantee that it will produce a serendipitous experience. There is no formula for reliably predicting when serendipitous discoveries will occur, although there seem to be cognitive and contextual conditions favourable to serendipitous experiences. For that reason, our approach concurs with that of Andre et al., who "propose an automation, acceleration and aid for the first half of serendipity – the discovery of a new piece of information. The second half of serendipity – the sagacity and wisdom needed to make the connection between pieces of information – remains dependent on the human" (Andre et al. 2009, 6). In other words, STAK cannot promise a serendipitous experience, but can only help to generate the conditions necessary for it to occur. Only the user can recognize meaningful and usable materials, and attach significance to their interaction with physical books and specific locations in the stacks. We hypothesize that drawing attention to unexpected resources of high value in close physical proximity to the user will help to create the conditions for serendipitous discovery.

Prototyping STAK

There exist many models of serendipity (e.g. Erdelez 2004; Makri and Blandford 2012b; McCay-Peet and Toms 2015; Rubin, Burkell, and Quan-Haase 2011), and this article does not permit space to detail each of them. There are, however, two elements that are often repeated in the literature: Noticing, and Capture and Recall. It is these elements of the serendipitous experience that we feel are most important to emulate in the first iteration of STAK.

(i) Noticing

The fact that our test subjects did not manage to stay focused on a single search task, even when instructed and paid to do so, might be seen as a side-effect of digital distraction. Distraction is generally presented as a negative side effect of digital interfaces. Scholars tend to prefer the idea of immersive reading over distraction, even though "[s]ustained discontinuous reading seems to be characteristic of scholarly expert reading," as Hillesund notes (Hillesund 2010). In a study of scholarly reading habits, Hillesund observes that scholars have all "in different ways developed strategies to avoid being distracted or tempted by the [computer] screen while reading, usually positioning their body so as not to stare directly into the beckoning display." Moreover, almost all research into augmented reality (AR) interface design registers concern that these systems might distract users from the task at hand, rather than enabling it. (The only dissenting results we found were produced by a team of medical researchers who used virtual reality to distract patients who are in pain [Malloy and Milling 2010]).

By contrast, our goal is to use AR to heighten the *positive* aspects and affordances of distraction. We see serendipitous noticing as a kind of meaningful distraction for the researcher, providing that it connects to an earlier research interest not currently in the foreground of her attention. This is something that Erdelez's model has repeatedly stressed, as it is difficult for users to keep track of more than one information need at a time (Erdelez 2004). We are currently experimenting with various interfaces to bring to a user's attention nearby items of possible relevance—effectively, we aim to remediate the experience of noticing the "big red book" (Greenspan et al. 2015). For instance, if a user stops at a particular location, STAK's motion-sensing module might interpret her hesitation as an expression of heightened interest in the closest stacks, and start returning potentially serendipitous resources based on her location.

(ii) Capture and recall

One of the most important elements of the serendipitous experience is being able to capture and retrieve information while browsing. Researchers have devoted much attention to improving search algorithms, but until recently have devoted little effort to helping users retrace their steps and recreate the circumstances that enabled previous discoveries. While bookmarking and citation tools like Zotero and Mendeley provide for this type of capturing outside of the library interface, STAK will use geolocation to give users a more precise recall of their prior visits to the physical stacks. As users walk among the library shelves, they will be able to interact with the materials they notice either by taking photographs of the physical items, pages or passages that interest them, or by taking screenshots of the digital materials that STAK determines to be relevant to the user's research interests. As these images are collected, STAK will tag them with the location, time, and date at which each search occurred, and provide track routes so that users can retrace and re-live their browsing experiences. In this way, STAK will provide precisely the sort of library wayfinding functionality that Shatte, Holdsworth and Lee propose as an area of future research for AR library apps (Shatte, Holdsworth and Lee 2014).

Future work

Our next round of user tests will be designed to gauge whether or not our approach can generate serendipitous experiences. In order to move from proof-of-concept to working prototype, we aim to:

- Improve our dynamic user model management and resource mining system.
- Determine the best approach to indoor geolocation using a combination of GPS, Radio Frequency Identification (RFID), Bluetooth beacons, and/or Wi-Fi triangulation. While the advent of Google Indoors for wayfinding may eventually provide a simple solution that will function natively with the StoryTrek architecture, at present the accuracy of indoor geolocation using GPS and Wi-Fi alone is highly variable, especially in the dense physical layers of library stacks.
- Design, implement, and test several interface prototypes, evaluating their effectiveness in encouraging the noticing and capturing of relevant resources.

We plan to test STAK's search and retrieval algorithms and interface design separately, in iterative stages. To evaluate the effectiveness of our interface designs, we will first simulate functionality without relying on actual geolocation or search algorithms, by retrieving online information from a constrained dataset relevant to the user's pre-determined location in the stacks. Each site test will be followed up with post-test interviews in which we ask subjects to elaborate on their experiences of STAK's perceived functionality, accuracy, and user interface design. Once we have decided upon a functional interface design, we will implement full geolocational functionality to test and fine-tune STAK's search and retrieval algorithms. These algorithms will be grounded both in theoretical models of serendipity research, and in qualitative user tests conducted at both Carleton University and Western University.

We plan ultimately to release STAK through an open-source code management system, such as GITHub. Only a large install base can generate the feedback necessary to verify that the serendipitous experiences of our test subjects extend to researchers in general. We also hypothesize that, when used within a wide variety of physical library spaces within differing cultural and geospatial contexts, STAK could generate many other kinds of user experiences that cannot yet be anticipated.

Works cited / Liste de références

André, Paul, MC C. Schraefel, Jaime Teevan, and Susan T. Dumais. 2009. "Discovery is never by chance: Designing for (un) serendipity." In*Proceedings of the Seventh ACM conference on creativity and cognition, Berkeley, CA, October 27-30*, 305-314. New York: ACM.

Andrew, Liam. 2014. "I'm feeling lucky: Can algorithms better engineer serendipity in research — or in journalism?" Nieman Lab. July 16. Accessed October 24, 2016. http://www.niemanlab.org/2014/07/im-feeling-lucky-can-algorithms-better-engineer-serendipity-in-research-or-in-journalism/.

Borgman, Christine L. 2009. "The digital future is now: A call to action for the humanities." *Digital Humanities Quarterly* 3.4. http://www.digitalhumanities.org/dhq/vol/3/4/000077/000077.html.

Brown, Susan. 2011. "Don't mind the gap: Evolving digital modes of scholarly production across the digital-humanities divide." In *Retooling the humanities: The culture of research in Canadian universities*, 203–31. Edmonton: University of Alberta Press.

Burkell, Jacquelyn, Anabel Quan-Haase, and Victoria L. Rubin. 2012. "Promoting serendipity online: Recommendations for tool design." In *The proceedings of the 2012 iConference: Culture, Design, Society, University of Toronto, ON, February 7-10*, 525-526. New York: ACM.

Chen, Xiaotian. 2010. "Google Scholar's dramatic coverage improvement five years after debut." *Serials Review* 36.4, 221–26.

Denton, William. 2014. "Libraries and archives augmenting the world." In *The top technologies every librarian needs to know: A LITA guide*, edited by Kenneth J. Varnum, 27-41. ALA TechSource. http://yorkspace.library.yorku.ca/xmlui/handle/10315/27527.

Erdelez, Sanda. 1999. "Information encountering: it's more than just bumping into information." *Bulletin of the American Society for Information Science* 25.3: 26–29.

———. 2004. "Investigation of information encountering in the controlled research environment." *Information Processing & Management* 40.6: 1013–25.

Fyfe, Paul. 2015. "Technologies of serendipity." *Victorian Periodicals Review* 48.2: 261–66.

Georgas, Helen. 2015. "Google vs. the library (part III): Assessing the quality of sources found by undergraduates." *Portal: Libraries and the Academy* 15.1: 133–61.

Given, Lisa M., and Gloria J. Leckie. 2003. "'Sweeping' the library: mapping the social activity space of the public library." *Library & Information Science Research* 25.4: 365–85.

Greenspan, Brian and Jennifer R. Whitson. 2013. "Whether to play or preserve the past?: Creating the forgotten worker quest." In *Proceedings of the 8th International Conference on the Foundations of Digital Games: FDG 2013, Chania, Crete, Greece, May 14-17*, 298–305. Santa Cruz, CA: Society for the Advancement of the Science of Digital Games 2013. http://www.fdg2013.org/program/papers/paper39_greenspan_whitson.pdf.

Greenspan, Brian, Jiayu Li, Kim Martin, David Mould, and Anabel Quan-Haase. 2015. "The big red book: a demonstration of serendipitous tool for augmenting knowledge (STAK)." Paper presented at *Joint CSDH/SCHN Digital Humanities Conference*, University of Ottawa, Ottawa, ON, June 1-3.

Hahn, Jim. 2012. "Mobile augmented reality applications for library services." *New Library World* 113.9: 429–38.

Harpold, Terry. 2008. *Ex-foliations: reading machines and the upgrade path*. Minneapolis: University of Minnesota Press.

Hillesund, Terje. 2010. "Digital reading spaces: how expert readers handle books, the web, and electronic paper." *First Monday* 15.4. http://firstmonday.org/article/view/2762/2504.

Hoeflich, Michael H. 2007. "Serendipity in the stacks, fortuity in the archives." *Law Library Journal* 99.4: 813–27.

Howland, Jared L., Thomas C. Wright, Rebecca A. Boughan, and Brian C. Roberts. 2009. "How scholarly is Google Scholar? A comparison to library databases." *College & Research Libraries* 70.3: 227–234.

Huang, Yo-Ping, Tsun-Wei. Chang, and Wei- Po, Chuang. 2007. "An interactive handheld device-based guide system using innovative techniques." In *ICICIC '07: Proceedings of the Second International Conference on Innovative Computing, Information and Control, Kumamoto, Japan, September 5-7*, 217. Washington D.C.: IEEE Computer Society. doi:10.1109/ICICIC.2007.162

Kemman, Max, Martijn Kleppe, and Stef Scagliola. 2014. "Just Google it – digital research practices of humanities scholars." In *Proceedings of the Digital Humanities Congress 2012: Studies in the Digital Humanities, University of Sheffield, September 6-8*, 1-17. Sheffield, UK: HRI Online Publications. Accessed November 4, 2016. http://arxiv.org/abs/1309.2434.

Makri, Stephann and Ann Blandford. 2012a. "Coming across information serendipitously – Part 1: A process model." *Journal of Documentation*68.5: 684–705. Accessed November 2, 2016. http://www.emeraldinsight.com/journals.htm?articleid=17051067.

———. 2012b. "Coming across information serendipitously – Part 2: A classification framework." *Journal of Documentation* 68.5: 706–724. Accessed November 2, 2016. http://discovery.ucl.ac.uk/1341009/.

Malloy, Katherine M., and Leonard S. Milling. 2010. "The effectiveness of virtual reality distraction for pain reduction: A systematic review." *Clinical Psychology Review* 30.8: 1011–18.

Mangen, Anne. 2008. "Hypertext fiction reading: haptics and immersion." *Journal of Research in Reading* 31.4: 404–19.

Martin, Kim and Anabel Quan-Haase. 2013. "Are e-books replacing print books? Tradition, serendipity, and opportunity in the adoption and use of e-books for historical research and teaching." *Journal of the American Society for Information Science and Technology* 64.5: 1016–1028.

Martin, Kim and Anabel Quan-Haase. 2016. "The role of agency in historians' experiences of serendipity in physical and digital information environments." *Journal of Documentation* 72.6: 1008-1026.

McCay-Peet, Lori. 2013. "Investigating work-related serendipity, what influences it, and how it may be facilitated in digital environments." PhD diss., Dalhousie University. Accessed November 2, 2016. http://dalspace.library.dal.ca/handle/10222/42727.

McCay-Peet, Lori, Elaine G. Toms, and E. Kevin Kelloway. 2015. "Examination of relationships among serendipity, the environment, and individual differences." *Information Processing and Management* 51.4: 391–412.

McCay-Peet, Lori and Elaine G. Toms. 2015. "Investigating serendipity: how it unfolds and what may influence it." *Journal of the Association for Information Science and Technology* 66.7: 1463–1476.

McClellan III, James E. 2005. "Accident, luck, and serendipity in historical research." *Proceedings of the American Philosophical Society* 149.1: 1–21. Accessed November 2, 2016. http://www.jstor.org/stable/4598905.

Quan-Haase, Anabel, Kim Martin, and Lori McCay-Peet. 2015. "Networks of digital humanities scholars: The informational and social uses and gratifications of twitter." *Big Data & Society* 2.1: 1–12.

Race, Tammera M. 2012. "Resource discovery tools: supporting serendipity planning and implementing resource discovery tools in academic libraries." *DLTS Faculty Publications*. Paper 22. http://digitalcommons.wku.edu/dlts_fac_pub/22/.

Reilly, Derek, Malcolm Rodgers, Ritchie Argue, Mike Nunes, and Kori Inkpen. 2006. "Marked-up maps: combining paper maps and electronic information resources." *Personal and Ubiquitous Computing* 10.4: 215–226.

Repanovici, Angela, Mihai Turcanu, Luciana Cristea, Mihaela Baritz, and Ioana Moisil. 2009. "Smart library: RFID implementation in libraries." In *Proceedings of the 8th WSEAS International Conference on Artificial Intelligence, Knowledge Engineering and Data Bases*, edited by Leon Trilling et al., 523–526. Stevens Point: World Scientific and Engineering Academy and Society (WSEAS).

Rubin, Victoria L., Jacquelyn Burkell, and Anabel Quan-Haase. 2011. "Facets of serendipity in everyday chance encounters: A grounded theory approach to blog analysis." *Information Research* 16.3. Accessed November 2, 2016. http://informationr.net/ir/16-3/paper488.html.

Satpathy, Lalatendu and Anijo P. Mathew. 2006. "RFID assistance system for faster book search in public libraries." In *CHI '06 Extended Abstracts on Human Factors in Computing Systems*, 1289–1294. New York: ACM.

Schaffner, Jennifer and Ricky Erway. 2014. *Does every research library need a digital humanities center?* Dublin, OH: OCLC Research. http://www.oclc.org/content/dam/research/publications/library/2014/oclcresearch-digital-humanities-center-2014.pdf.

Shahid, Syed, M. 2005. "Use of RFID technology in libraries: A new approach to circulation, tracking, inventorying, and security of library materials." *Library Philosophy and Practice* 8.1. Accessed November 2, 2016. http://www.webpages.uidaho.edu/~mbolin/shahid.htm.

Shatte, Adrian, Jason Holdsworth, and Ickjai Lee. 2014. "Mobile augmented reality based context-aware library management system." *Expert Systems with Applications* 41.5: 2174–2185.

ShelvAR. 2013. The Augmented Reality Center, Miami University. Accessed November 2, 2016. http://shelvar.com/ (now preserved at https://web.archive.org/web/20160616214311/http://www.shelvar.com/).

Toms, Elaine G., and Heather L. O'Brien. 2008. "Understanding the information and communication technology needs of the e-humanist." *Journal of Documentation* 64.1: 102–130.

Wang, Yi-Shiang, Chih-Ming Chen, Chih-Ming Hong, and Yen-Nung Tsai. 2013. "Interactive augmented reality game for enhancing library instruction in elementary schools." In *Proceedings of IEEE 37th Annual: Computer Software and Applications Conference Workshops (COMPSACW), Kyoto, Japan, July 22-26*, 391–96. IEEE. Accessed November 4, 2016. https://scholar.lib.ntnu.edu.tw/zh/publications/interactive-augmented-reality-game-for-enhancing-library-instruct.

Williamson, Kirsty. 1998. "Discovered by chance: The role of incidental information acquisition in an ecological model of information use."*Library & Information Science Research* 20.1: 23–40.