Curators in the Loop: a Quality Control Process for Personalization for Tangible Interaction in Cultural Heritage

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Abstract. Personalization research for the Cultural Heritage domain has mostly focused on supporting the visitors by automatically creating the narratives and the visit experience. The meSch project shifts the focus of research from visitors to curators and re-designs the personalization process in a context of tangible interaction, to strengthen the role of human-supervised steps in the definition of the adaptive structures for both the content and the interaction. Targeting the work of curators opens the way toward personalization to become deployable in real and complex settings: professionals in control of the platform will use personalization in any context they consider worth it, to adapt both the content and the interaction behavior of smart objects delivering it, and will monitor the quality of adaptive experiences from the design to the actual onsite delivery and subsequent follow-up online exploration. This paper presents the articulated personalization research agenda of the meSch project.

Keywords: personalization architecture, human-supervision, tangible interaction

1 A Story of Research Successes and of Scarce Exploitation

Cultural heritage has been a privileged application domain for personalization technologies for many years, since visitors can highly benefit, during cultural heritage exploration, from individual support that takes into account contextual and personal attributes and visitors' evolving behavior during the visit, given that visitors are highly heterogeneous and require different types of information, at different levels of detail [9][26].

Research efforts have successfully demonstrated how personalization technology can affect various aspects of the interaction with visitors: the information selected for presentation; the organization of the overall presentation; the media used to interact with users; the individual vs. group type of adaptation; the interaction modalities [2]. Starting from the first web-based adaptive hypermedia systems [24][16] in the '90s, personalization researchers have progressively taken advantage of novel technology

like portable devices, wireless connectivity, localization methods, and powerful platforms to experiment adaptive approaches also within technology enhanced mobile scenarios [20][25] or virtual reality applications [6][3]. Experiences of combining personalization opportunities with tangible and embodied interaction in the museum setting are instead still limited [12]. Furthermore, the convergence of internet and wireless technology has made the exploration of (digital and material) cultural heritage a continuous process, starting before the visit and ideally never ending, as the user is able to plan the visit online, visit the site, and then "revisit" places of interest online again [14].

However, despite of over 20 years of research in personalization for cultural heritage [2] only a few examples like the CHIP [11], PEACH [25], and PIL [15] projects reached a large scale evaluation with museum visitors. Conversely, personalization services in areas like e-commerce applications, news alerts, support to digital content access, tourist guides [1][5] have left the lab and are being used commercially. The reasons for personalization in cultural heritage to lag behind are many [2], including difficulties in modeling groups, and the challenge of evaluation. Practical considerations, such as cumbersome technological infrastructures (e.g. sensors to be placed indoors for position detection), or an unbalanced cost-benefit [4] have a significant impact. One of the challenges identified by Ardissono et al. [2] is the lack of standardization and the often idiosyncratic data representation that on one hand allows sophisticated personalization but on the other limits the reuse of existing digital resources such as heritage databases. In essence, what hinders the actual adoption of personalization in cultural heritage is the complexity that makes it prohibitive for institutions in terms of time (to prepare the data in the right format) and technical expertise, and the high cost against benefit for just a small part of the audience.

1.1 Curators and Exhibition Designers in the Loop

One additional aspect that it is usually underestimated in analyzing the weaknesses of personalization exploitation is the scarce role that is often reserved for curators and authors. Indeed, curators have long been considered as a precious source of expert information on how to compose effective labels, audio commentaries and texts to derive rules and algorithms to be implemented in personalization systems, in the utopic view that the system, when appropriately instructed by programmers and equipped with properly annotated data sources, can then autonomously decide how to select and dynamically compose the bits of content to deliver all the required forms of personalization in whichever situation. This approach inevitably suffers from problems like lack of portability, reusability, robustness, difficulties in checking the validity of system outputs,… all problems that hinder the deployment in real settings.

In this paper we discuss how the process of defining adaptive structures can be improved, made more flexible and portable, by identifying and separating the strength of automatic mechanisms from that of the human judgment and effectively synchronizing the activities of the two actors to achieve a superior quality of the results, a technique effectively used in other cases of human-intelligent systems collaboration [7][19] and of end-user development [10]. We present here the research agenda of the

meSch project, where we are pushing the boundaries of investigation even further, by uncovering the potential of combining (i) the personalized presentation of digital content with (ii) tangible interaction with technology augmented exhibits or spaces and (iii) social interaction. meSch adopts a co-design approach where curators, designers, computer scientists and engineers all work together to explore the possibilities offered by personalization technology. We are currently in the process of concepts generation and sketching-in-hardware what a personalized visit can be and in analyzing the technical requirements that the needed forms of personalization impose on the system architecture. Later in the project we will shift our attention to the authoring stage and the authoring tools that will be again co-designed with heritage professionals.

2 Personalization in a Scenario of Tangible Interaction

In meSch we envisage a cultural space filled with smart objects, each with their own (adaptive) stories embedded therein, that will be revealed if and when conditions are right, e.g. visitors have reached the right time in the storyline, or a group of them is acting in a certain way, or another smart object is close by. The role of curators and exhibition artists is fundamental in conceiving the very first idea of the intended educational/experiential mission of the exhibition, in selecting the most meaningful and evocative objects, in imagining alternative threads of narration, in deciding when and how digital information should be unlocked. Fig. 1 illustrates the overall production cycle for personalized experiences.

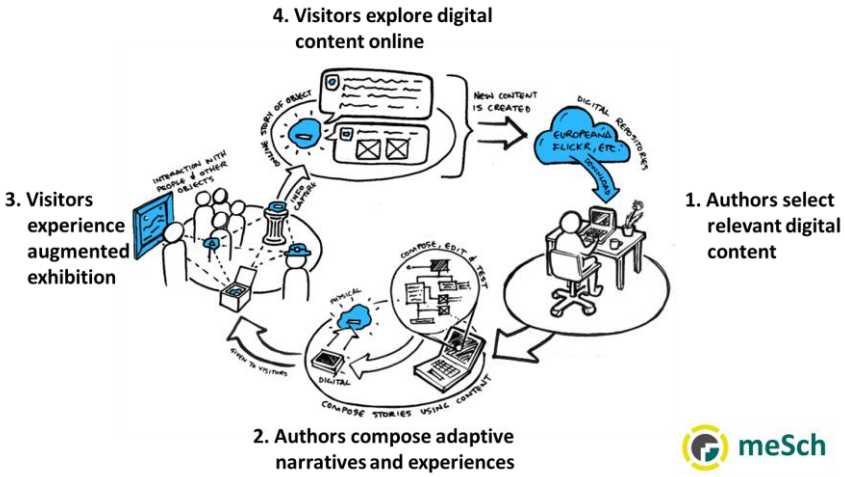

Fig. 1. The meSch production cycle for personalized experiences in a cultural space.

1) Curators conceive a new exhibition, or an adaptation to an existing one, and select pivotal objects (possibly replicas) that have been augmented with digital capabilities through the embedding of miniaturized multisensory integration platforms (e.g. Arduino, .net Gadgeteer, Raspberry Pi) or of more traditional devices (e.g., an mp3

player or a smartphone of which only the screen is made visible)[23][18]. They edit or select from proprietary or public domain multimedia databases (like Europeana [8]) suitable chunks of digital content related to the objects.

2) With the help of an authoring tool they assemble the chunks of content into threads of narration and select adaptive rules for their presentation. Similarly, they associate enabling (inter)actions over the objects to release the contents. The resulting structures for adaptive experiences are then downloaded onto the smart objects that will compose the exhibition.

3) Visitors approaching the smart objects at the exhibition site, either individually or in groups, will be able to experience the physical dimension of exhibits as well as the (social) engagement that may be favored by the tangible interaction coupled with the contextual delivery of mindful content such as a coherent story or an appropriate soundscape.

4) The logs of what visitors have experienced onsite, will translate into a digital souvenir that become the basis for a further personalized exploration online, after the visit.

2.1 A Quality Control Process for Personalization

meSch extends the typical architectures for personalization in the cultural heritage domain [2], by designing a multistage personalization process that decouples the inner personalization algorithms from content management issues, thus making it easier to plugin new digital resources and new domains, and implements a range of services able to respond differently according to the specific personalization stage, i.e. to be used within the smart objects vs. to be used online, offered to the authors or to the visitors. The personalization process has been designed to include human-supervised content structuring and experience design required to get high quality results, an essential requirement for the enjoyment of cultural heritage. Fig. 2 depicts, at a high level, the multilayer personalization process in meSch.
To address the issue of domain portability in a principled manner, a specific data access component will devise mechanisms for the effective integration of multiple digital repositories both public such as Europeana, or local, as museum archives, or Web2.0 such as DBpedia for the use of recommender functionalities. A uniform API will be made available to personalization services to grant data access, thus hiding the complexity of query and data mapping. This will facilitate the plug-in of new digital resources, also with different levels of content annotation richness. meSch puts a lot of emphasis on reusing existing digital resources: although this can limit the performance of the personalization mechanisms as the existing metadata may not hold useful details, we consider the exploitation of existing data a challenge worth tackling [2]. Indeed if the final interaction will be considered good enough this approach will open up many possibilities for the adoption of personalization by cultural heritage as there is no added costs for data preparation.

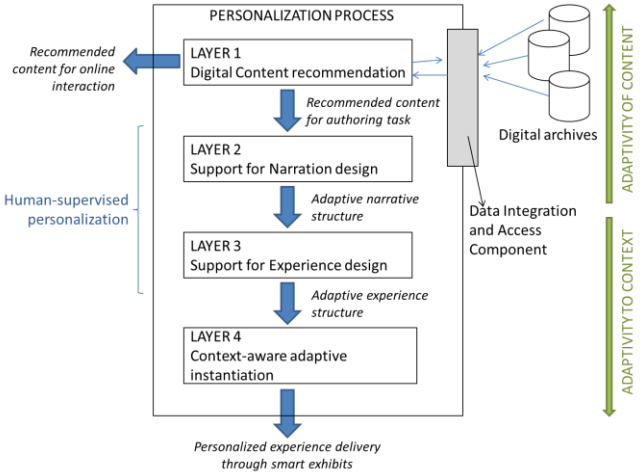

Fig. 2. Multilayered personalization process with human supervision

Four main stages of personalization compose the architecture:

1. the digital content recommendation service provides a flexible interface to different digital content archives (Layer 1);
2. the second stage supports curators in the effective use of the recommended content, its principled selection and the composition of alternative narrative threads according to educational and communicative goals (Layer 2);
3. in the third stage, the system supports the exhibition designer in describing how the narrative threads can be activated through tangible interactions with the objects and social behavior (Layer 3);
4. at the low-level, context-aware adaptive instantiation algorithms model decisions to be taken autonomously by the augmented objects at visit time according to the specific interaction context (Layer 4).

As shown in Fig. 2, Layer 1 and Layer 4 are performed by the system in an autonomous way, Layer 2 and Layer 3 are instead the two points where the human expertise comes into play. The figure also highlights a clear separation between the retrieval and composition of the content (layers 1 and 2) and the definition of the context (layers 3 and 4), as we distinguish two types of personalization: *personalization of content* pertains what (information or other) will be provided to visitors; *personalization in context* pertains the way in which the content is delivered. This split maps two distinct set of features, e.g. different content for different visitors groups or for different topics; different context for individual or social settings. It also maps two different types of cultural heritage professionals: *the curator*, often a scholar of the subject; and *the exhibition designer*, generally a creative mind, often an architect or a graphic designer. Curators will be able to specify which digital contents couple which real artifacts for which visitor group, while exhibition designers will decide the most appropriate effects to stimulate interaction among visitors and with the artifacts to unlock

the digital content. Both professionals should be supported in their tasks of preparing the personalization structures that will deliver to visitors personalized content in context. This allows for multiplicity: the same structured content can be loaded on different smart exhibits so the content will be activated by different interactions (e.g. energetic children will have to work harder on the objects to release the content than older visitors); and the same smart exhibit can hold different structured content so that different content will be offered for the same interaction. A clear advantage of this approach is sustainability as the initial investment for the smart exhibits covers a number of different exhibitions each one with a different content. Moreover the same exhibition could travel to different institutions that will change the content to suite their visitors, e.g. translating it in the local language.

This approach poses the challenge of defining, implementing and evaluating models and tools for a human and a system that collaborate in building personalized tangible experiences for cultural sites and of determining the optimal division of responsibilities and roles between, for example, a curator authoring multiple narrative threads for schools and a recommender system that is actively finding new digital material for him to choose from.

3 Multipurpose Personalization Services

The meSch personalization architecture is currently under specification. An articulated research agenda has been put forward for each of the different personalization layers/tasks, as discussed in the following sections.

3.1 Content Recommendation Services

By definition, recommendation services are functions that exploit information about (i) users' personal characteristics, preferences and interaction history, (ii) semantic features of item descriptions or information articles and/or evaluation ratings, and (iii) possibly the behavior of a community of other users, to suggest items, pieces of information or services within a large information space, that best suit the user's needs in a given situation and context [21]. Recommenders have reached good maturity and robustness to be deployed in real setting applications in diverse domains and for diverse (context-dependent) user tasks [1][5]. For this reason, they represent a viable solution to introduce a first personalization layer over content extracted from knowledge sources to tune search results to the interaction context and task.

In meSch, recommendation techniques will work on top of meta-search results to additionally estimate the relevance of material (measured with various metrics, like similarity, divergence, novelty, serendipity), whenever this is made possible by the quality of the annotations in collection data. Several recommendation strategies will be evaluated with users/authors to find the most effective balance with respect to the quality of user experience. This layer serves two different requests for personalized content: (a) curators' content inspection through the authoring toolkit used for composing narrations and (b) visitors' information requests from the online interface.

Recommendation for the authoring task.
The author is responsible for the ultimate choice of the most appropriate content to be assembled within the ecology of smart objects, however he might not be familiar with all the contents available in external databases. We envisage a recommender system to run in the background and to support the author who is searching, selecting and composing content into narratives, by appropriately reordering or highlighting search results. We see this partnership between author and recommender system as an opportunity for the author to discover new content that can enrich his current effort, as well as a way to become aware of what is available in the repositories. Content-based recommendation strategies [17] can be used to reorder the results according to their similarity/novelty with respect to the other contents already selected for presentation (e.g. if the author is composing a narrative thread conceived for primary school children on soldiers' life in the trenches during WWI and some photographs have been selected by the curator from the local museum database, the system may suggest similar material extracted from Europeana [8], as in Fig. 3).

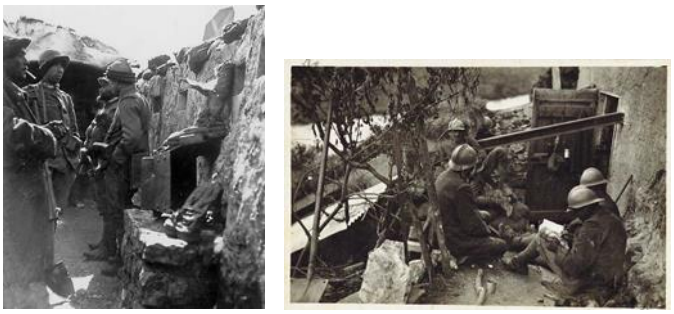

Fig. 3. Life in the trenches. On the left, picture from the local archives of the Museo Storico Italiano della Guerra. On the right, picture retrieved from Europeana (provider Museo Centrale del Risorgimento)

A recommender would also be able to automatically manage query relaxations [22] to suggest alternative content that may fit the narrative context as well (e.g., same searched content but in different media – image of a fort vs. 3D reconstruction; or different type of memento – letter vs. photography; or different period – photos of the same artifact in different periods).

When new smart objects have to be added to an existing exhibition, the recommendation services can take advantage, through collaborative-based recommendation strategies [13], of the actual behavior of users during onsite and online interaction to better tune the suggestion of additional information to be included in the new objects. For example, when adding to the exhibition a new smart object with audio/visual output capacity (e.g. a book with an embedded tablet), the system can suggest to the author texts from soldiers' letters or diaries, in case this content is similar to the type of information items that were more preferred by users, in previous onsite and online explorations.

Recommendation for online interaction.
In the meSch vision, individual logs of visitors' behavior during the visit to the cultural site will be used to dynamically compose data souvenirs and to bootstrap the online personalization of digital content without the need for the user to input explicit settings (thus solving the so called cold start problem). The data souvenir of the completed visit offers the starting point for online exploration, it gives hooks for the recommender to find additional related material. Users can save into their data souvenir the additional info objects explored online: this provides to the systems an explicit feedback about specific user interest and can be used as "rating" to enforce quality to collaborative reasoning and subsequent content suggestions. The recommender system will select (i.e., filter and re-order) the links proposed for further exploration by combining: (a) Content-based strategies that identify the information items, media types, subjects that most attracted the user interest during his visit (e.g. several interactions with biographic texts vs. historical descriptions; several pictures vs. audio files) and assign appropriate relevancy weights to additional information objects for exploration; (b) Collaborative-based strategies that exploit the online exploration behavior of users with similar onsite experience to better predict items of interest for the current user.

3.2 Adaptive Content Authoring

Content personalization for cultural heritage, for onsite use in particular, is a complex process that needs to take into account several components, e.g. the content, the description of the physical space, and the conditions (or rules) under which a certain content is delivered according to the contextual features. This unquestionable complexity calls for a collaboration between the author and the system to constrain the author to well-formed rules and schemas while at the same time gives space to creativity to generate engaging narrations. One example of a graphic tool purposefully designed to support non-technical users in composing the data structure needed for personalization was developed and used in the HyperAudio project [20]. Through drag-and-drop interaction, users were able to compose activation networks and run them in simulation mode to test if the personalization conformed to expectations. Templates were offered to speed up the editing and users only needed to load the desired content in the specific node [20]. The outcome of this activity was a set of data properly annotated into a micro-network and ready to be used in the onsite trial. In meSch we plan to exploit a similar approach. Through co-design activities with stakeholders we will first unpack the process curators and artists go through when creating a new exhibition or new educational material supporting visits (e.g., leaflets for school group activities when in the museum and back in class). This study will feed the identification of: best practices for content selection and composition, forms of personalization and presentation strategies used by museum staff, typical patterns of narrative. This will allow defining and testing various classes of adaptive composition rules and of pre-packaged schemas, like for example skeletons for composing narratives based on a temporal sequence (e.g., the life stages of a historical character), or reflecting a certain topic organization (e.g., comparison of different making tech-

niques), or alternative object interpretations (e.g., historical vs. artistic description). The outcome will be a set of validated, ready-to-fill templates for adaptive narrative threads to facilitate authors' composition work, to be made visually available in the authoring tool. Mechanisms to create templates from scratch will be however offered to those users more interested in technology and inclined to experiment.

3.3 Adaptive Interaction Authoring

As meSch will bring personalization into smart objects augmented with interaction abilities, how the objects are going to deliver the adapted content according to the context of use needs consideration. The personalization of the interaction is complementary to the personalization of the content, as the (adaptive) narration can be delivered through alternative objects, by different activating actions and social interactions. For example, in a treasure hunt setting a smart object might reveal its contents just when all the members of the same competing group are close to it, whereas in an individual visit setting the content may be unlocked by simply picking the object up, and if the object is manipulated for a little longer additional information is presented. This specific stage of personalization authoring requires to define a vocabulary of actions and interactions that can be implemented by the hardware platform. In this way the editing is based on the type of interactions that can be actually built.

Through co-design activities with curators and technicians we will define and test various classes of interaction rules and pre-packaged schemas, like for example skeletons for fostering social situations (e.g., with extensive use of collaborative multi-user actions such as people marching in line), or object manipulation (e.g., with content disclosed by varied or prolonged manipulations, such as wind up the radio to play war bulletins), or objects search (e.g. in a sort of treasure hunt or to find your enemy to unlock the full story of the battle). The outcome will be a set of validated, ready-to-fill templates for interaction to be matched onto the narrative treads composed in layer 2 of the personalization process (Fig. 2). By decoupling the layer of content from the layer of interaction, it will be possible for an author to easily use multiple alternative narrative templates with the same interaction template and vice versa, the same narrative template can be applied to multiple interaction templates.

3.4 Onsite Adaptive Experience Delivery

The output of layers 1-3 of the personalization process depicted in Fig. 2 is the human-supervised creation of adaptive structures of experience (i.e., content + interaction) to be downloaded into the smart exhibits. The last layer of the personalization process instantiates these structures according to the actual behavior of visitors and the context they are in, i.e. it performs the automatic adaptation of the experience to a specific visitor, or a group of visitors within their specific context, at the very moment when the interaction with the smart exhibits takes place.

Layer 4 of the personalization process is based on algorithms for low-level adaptivity decisions to be taken autonomously by the augmented objects according to the specific interaction context. These algorithms are required to relieve authors from

specifying the exact object behavior in all possible contextual situations. This includes resolving conflicts when alternative object behaviors are possible. For example, in case there are four people potentially affected by a presentation, the final decision of alternative audio is based on content mediation with respect to the narrative threads currently followed by the four people. Similarly, objects and locations that support different single-user and multi-user actions (like picking up, holding, collecting, sharing…) will need low-level, instant decisions on how to prioritize interaction events.

4 Conclusion

The meSch project aims at advancing the state of the art in personalization for cultural heritage by integrating principles of context-awareness related to onsite, tangible and socially situated interaction with principles of content adaptation and by embedding these different personalization mechanisms into physical objects thus transforming them into smart exhibits. The project envisages a tool to empower curators to make the most of their (digital and physical) collections and to create compelling visitor experiences. Complexity reduction is achieved through a human-supervised multi-layer personalization architecture that splits the adaptivity of the content from the adaptivity of the interaction, with the system relieving the author from the most complex tasks and assisting him to achieve a high quality result. The final aim is that of taking personalization of cultural heritage to the large scale offered by the existing repositories of digital content and to test a sustainable architecture (i) able to serve different personalization tasks, (ii) portable to different content and (inter)actions vocabularies, and (iii) easily reusable in different physical sites.

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