Enhanced User Experience and Behavioral Patterns for Digital Cultural Ecosystems

Invited Paper

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ABSTRACT

The world's digital content and media is growing rapidly at a never stopping rate. There are millions of digital media assets on display through mobile devices, home entertainment systems or computers. The vast pool of visual and audio information has to therefore be grouped in different ecosystems depending on their nature or intended audience to simplify the problem of searching, finding and personalizing datasets on demand. Though such is the case for the Digital Cultural Ecosystems, we still need to introduce number of smart methodologies to make the process of narrowing down vast number of digital assets in order to arrive at a desirable media and essentially personalize and automate the approach. In this paper, we propose a method that deals with the detection, extraction and personalization of media assets applied to the world of digital cultural ecosystems.

Categories and Subject Descriptors

Human computer interaction (HCI) - *HCI theory, concepts and models; Interactive systems and tools, User interface management systems.*

General Terms

Design, Human Factors

Keywords

Digital Culture Ecosystem; Digital Cultural Assets; Non-Formal Learning; Human Behavior; Sentiment Recognition; Emotion Recognition; Image and Speech Processing.

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1. INTRODUCTION

The great fragmentation of the major historical and cultural sources related to European history and culture in various digital collections, libraries and repositories puts on the agenda the question of providing users with opportunities for their joint consideration and study in order to fully utilize all semantic inter connections between them, overriding physical distance and the specifics of the digital storage of each source. Furthermore, the volume of digital cultural objects and data on them is growing rapidly. Possible approaches to solving this problem are linked to the creation of complex semantic-based, context-dependent models, or signal processing of captured human behavior through image and voice processing introducing simplicity and improving usage, research and delivery of large volumes of digital cultural resources, and supporting the "real-time" integration of these resources according the users' needs.

The paradigm of ecosystems for digital cultural assets (also called digital cultural ecosystems, DCEs) appears to respond to the growing willingness to share the wealth of cultural resources and continuous research and study of cultural treasures. These systems virtually assemble various digital collections, archives, virtual museums, digital libraries and cultural heritage sites in order to facilitate the access to their resources, bringing cultural content to new audiences in novel ways.

The paper discusses digital culture ecosystems and the processes of content aggregation, observation, and their study, as well as the users' roles and activities in the mentioned context. Main factors, related to the DCEs user experience and content usability issues are considered. Users' cognitive needs, goals, preferences, and interests have been carefully studied and become the starting point for the new DCE functionality. An approach for analysis and improved usage of digital cultural assets for non-formal learning purposes is presented. An attempt to solve the issue of personalization and user experience enhancement is proposed through the use of data analysis on selected media, such as image and speech processing.

2. DIGITAL CULTURAL ECOSYSTEM FEATURES

In nature, an ecosystem is an area, where organisms interact with one other as well as with the non-living parts of the environment. In the digital cultural ecosystem, various "digital organisms" (*viz.* collections, archives, virtual museums, digital libraries, cultural heritage site, *etc.*) also interact with one another as well as with the living part of the environment (*viz.* users) [13]. Formally, a digital cultural ecosystem can be huge, covering joint content management systems of one country or a region (similarly to a large forest or lake in the nature), but it can also be small, such as a virtual museum or a private collection of artifacts (the nature analogues: a puddle of water or only a tree). "Digital organisms" "work" through services and tools to satisfy their users. DCEs aggregate heterogeneous resources leaning on interoperability support of its building blocks (in [15] authors have proposed a solution for content interoperability between various digital libraries).

In the CultEcoSys project [9] we perceive *digital libraries (DLs), virtual museum, cultural website, etc. as small ecosystems for digital cultural assets.* For example, current cultural heritage DLs demonstrate wide range of applicable services and tools for re-using and repurposing digital assets (or objects, DCOs), paving the way for wider exploitation of cultural resources and boosting innovation. Figure 1 and Figure 2 depict the DL content flow, the main content units and the user's activities for manipulation in DL.

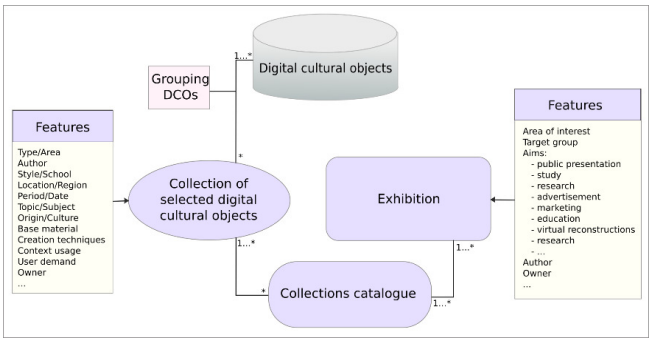

Figure 1. Content flow in a digital library

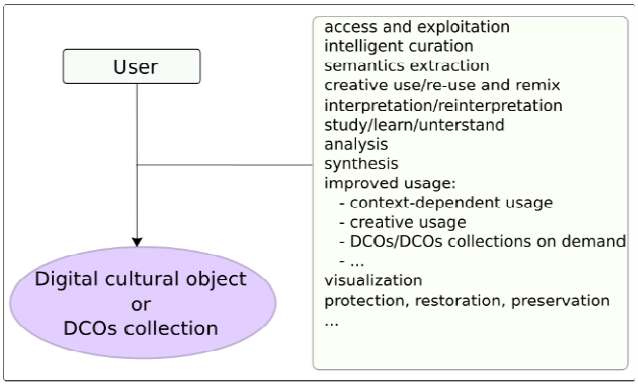

Figure 2. Main content units and activities for their manipulation in a digital library

Digital cultural objects are the smallest content units in the DCE. Context-based grouping of DCOs creates a collection with a wide variety of usage. The DCOs could be selected according to their type and area, author, style, school, location, date, subject, origin, context of usage, *etc.* The collections are saved in catalogues for further inclusion and display in exhibitions.

In general, the user's manipulations with DCOs and DCOs collections are related to: access and exploitation, curation, semantic extraction, use/re-use and remix, analysis, study, *etc.* [13].

The main content units and the activities for their manipulation can be extended according to the concrete DCE' aims, marketing and advertising strategies, target groups, *etc.* In this study, we concentrated on models and visions for improved use, research and delivery of digital cultural resources in DCE.

3. FACTORS RELATED TO THE DCEs USER EXPERIENCE. CONTENT USABILITY ISSUES

When the DCE user is a learner, or has more cognitive purposes in the environment, he/she has different learning-oriented needs and preferences that (should) affect the DCE functionality. These users expect from the DCE system a "personal facilitator" and not a "classroom" behavior, where their personality and needs are known and taken into account. Based on [7] the learning personalization is most generally defined as an adaptation of the learning process and its content to the personal characteristics and preferences of the learner, as much as possible.

Which are these educational needs and preferences that essentially should be considered as input parameters in personalization processes and what is their role in the construction of a learning plan and the selection of appropriate learning resources [1]? They identify and analyze some factors that can influence the extent and outcome of learning such as the learning style, learner goals/objectives, previous knowledge, educational level and difficulty, technical and other preferences (*e.g.* language, *etc.*).

Our research practices points to different factors that should affect even more the cognitive activities and selection and usage of the DCE content for learning, such as:

- The space in which learning takes place, its aesthetics and mood, user interfaces, visual elements, input devices, interaction with other users, possibility of dynamic changing of the knowledge observation place, even its realism;
- Interactivity and the DCE user immersion in the knowledge observation place;
- The "interplay" between the DCE user and the learning's narrative or the knowledge observation place as a whole;
- The "learnativity" content model - the concept of assembling content into higher-level objects, as it is defined by [18];
- The set of challenges the DCE user will face within the knowledge observation space. Synchronization of the challenges with the ability of the user;

- Keeping interests by: 1) Implementation of multiple difficulty settings for the different users; 2) Usage of non-trivial learning objects – applied games, puzzles, stories, conundrums, *etc.*

- Transforming the boring learning activities in a fun and adventures. The quality of the user experience – whether DCE user enjoys working with the e-system, or whether they find it frustrating;

- Setting awards for the efforts – Reward the DCE users for skill, imagination, intelligence and dedication;

- Enhancing the motivation by encouragement, diversity, and extended curiosity;

- Eventually, conscious awareness of the learning as a key engine for the future success.

It could be also mentioned the provision of creative experiences, learning-by-doing and role-playing scenarios.

Moreover, a key factor is the proper ***DCE user: learner*** model defining: the "who", or the degree of specialization in defining who is modeled and what the learner history is; the "what", or the cognitive goals, plans, attitudes, capabilities, knowledge, and beliefs of the learner; the "how" the model is to be acquired and maintained; and the "why", including whether to elicit information from the learner, give assistance, provide feedback, or interpret the learner's behavior [11]. Callan et al. [5] emphasized on investigating methods for building more robust, flexible and portable models of the complexity of users, tasks and contexts to inform the diverse possibilities for personalization. Targets for this work include being able to develop implicit rather than explicit methods for learning user preferences, which form the user models, and developing user models that are portable across applications, devices and environment. Perhaps the biggest challenge in this area will involve the development of user models that will drive personalization and recommender systems, which are rich enough to capture as much of the user's task environment (context, task, and situation), history, contribution to communities and individual preferences, as possible while conforming to a person's privacy choices.

Concerning to DCE usability issues, it could be said that usability plays a vital role for the successful usage of the environment and there have been valuable research findings years ago. As it is well known in the IT sector, the usability testing shows how the system is used by the user and how he/she gets benefits while using it. Buchanan & Salako [4] offered an integrated measurement framework, derived from the goal, question, metric paradigm, which provides a relatively comprehensive and representative set of system usability and system usefulness attributes and associated measures, which could be adapted and further refined on a case-by-case basis. They discussed some challenges to integrating user perspectives with technical developments, in terms of understanding those user perspectives, developing design processes that adequately accommodate them and ensuring adequate communications between all stakeholders in design.

Major problems appeared during the design of the software solutions (services, components, *etc.*), closely capturing the above discussed factors. Some of them concern the communication between the user and the software environment, which are in many cases ambiguous and even unsuited. Other are related with the formal presentation of the subjective issues such as user' skill, imagination, motivation, intelligence, dedication, *etc.* Moreover, in order to provide effective forms of personalized user experiences the focus must be on the design of the interaction per se as an integral part of the whole system. There is a need to develop multi-modal mixed initiative interfaces that draw on a range of user information seeking models. The requirement is thus for research to develop theories of interaction which underpin the design of applications and vice versa and which go beyond issues of simple elicitation, presentation and feedback.

4. CONTENT ANALYTICS IN A DIGITAL CULTURAL ECOSYSTEM

The long-term observation of the user's needs in DLs gives us the idea to look at analysis techniques and tools for improved usage of digital cultural assets [8, 6, 12, 13, 2] in DCEs, *incl.* new social usage, personalized usage, re-usage. The analysis includes a specific research/study about a particular object or a whole domain, and aims to collect useful information about their properties, characteristics, and integral parts. The main purpose is finding different characteristics about the objects or domains being analyzed, their structure, dependencies, internal and external relationships between their constituents, *etc.* Those are revealed by:

- determining the main trends in the development in the domain as well as the direction and dynamics of the development;

- discovering the key factors and conditions that directly affect the changes and developments in the domain; examining the degree of their influence and the direction of the changes;

- determining the degree of influence of the domain upon other related domains;

- identifying new trends in the development of the analyzed domain;

- defining current problems, boundaries and limitations in the development of the analyzed domain, as well as problems related to them and possible areas of improvement;

- evaluating the results in the domain's development.

The main users of the learning analysis method in the DCEs are learners and educators, but there could also be researchers/professionals, connoisseurs or tourists.

To implement the analysis method (mainly for learning purposes), the practical research/learning problem is divided into series of steps, leading to its solution. The steps are defined as a formula, which combines actions with content units [16]. The actions are based on the Bloom Taxonomy [3] and its "recommended vocabulary" of actions (called skills by Bloom), leading to results of the learning process (learning objective) in a certain area [14].

Furthermore, the following data analysis practices often use qualitative methods. The analysis process essentially involves three activities [11]: 1) data reduction: the process of selecting, focusing, simplifying, abstracting, and transforming raw data; 2) data display: the assembling of information in an organized way; and 3) conclusion drawing and verification: the observation of regularities, patterns, explanations, possible configurations, causal

flaws, and propositions that are verified and tested for their plausibility and validity.

Figure 3 depicts analysis actions provided to the users (*viz.* viewers: learner, educator, researcher/professional, tourist, and connoisseur; editor; moderator; administrator) of the digital cultural ecosystem. The analysis actions are separated into two types: Standard analysis and Specific analysis. As shown below, the standard analysis actions include the basic functionality for objects/collections search, review, selection and management. The specific analysis actions aim to improve the manipulation activities with DCE assets. We regard the following DCE content types: 1) digital cultural object; 2) DCOs collection (public DCOs collection, private DCOs collection, temporary DCOs group, *etc.*); 3) DCOs exhibition; 4) DCOs presentation; 5) DCOs learning project.

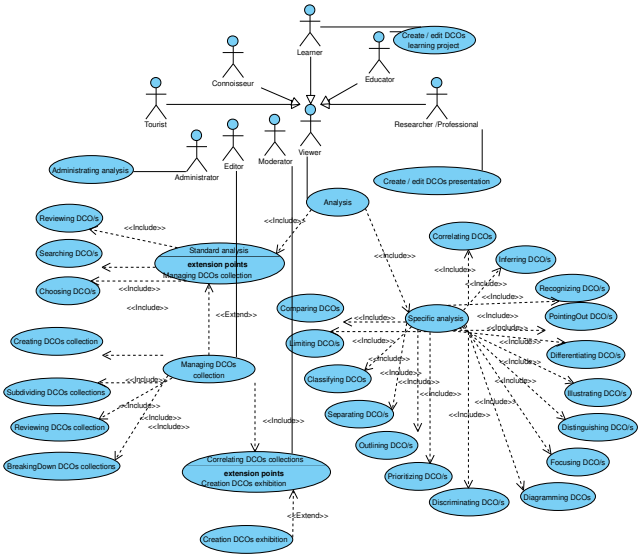

Figure 3. Analysis actions provided to the DCE users

Moreover, the different needs of the DCE actors have to be considered. For example, the learners and educators demand for essential information and services for developing collections in line with pedagogical requirements, *viz.* the creation of DCOs learning projects or learning context-dependent DCOs presentations. Other actors could have different needs.

The next scenario demonstrates a real usage of the DCE analysis actions by professionals - the artists.

The analysis actions (or part of them) will, for instance, assist the artists in their preliminary preparation (research, analysis) that they make before creating a new piece of artwork. DCE will give them possibilities for review and analysis of digital copies of artworks in a specific domain, topic, *etc*., also displaying additional descriptive information (metadata) about them (if available).

In particular, let the artist (*viz.* an iconographer) *plan to paint* a specific theme/character - "The Virgin" → ***General goal***.

In the DCE environment, he/she performs *a search by the specified theme/character* and *review of the found DCOs* → ***Task 1*** and ***Task 2***.

The next step is the *additional choice of a specific subset of the main theme*, for example, "The Virgin Hodegetria" → ***Task 3***.

The selected objects *are separated/arranged according to their creation time/period*, which brings different characteristics about the objects from iconographic and technological perspective/point of view → ***Task 4***.

After that, the system *could distinguish DCOs by a selected school*, point out DCO/s, including components for new artwork and prioritize one or several of them as a main sample/s → ***Task 5*** and ***Task 6***.

The final step is *the inferring phase*, which aim is to consider and present a conceptual solution/project of the new artwork, using the selected DCOs and their components → ***Task 7***.

Current solutions for improved access to the DCEs content and its effective usage are very restricted and mainly cover the basic analysis actions, mentioned above. The idea for creative and satisfying user experience in the context of advanced content manipulation is realized only by extended search. DCEs do not even provide a minimal content analysis functionality. When the user is a learner/researcher, or has learning purposes in the environment (which is very common), such "one size fits all" solutions are not enough to satisfy his/her needs [2]. The reasons for this gap are the low personalization and "real-time" integration of content according to the users' interests and needs in these systems, non-effective content exploitation, and the missing context-based usage of the resources.

5. IMPLICIT FACTORS OF HUMAN BEHAVIOR

As mentioned in section 3, the goal of improving user experience is to develop implicit rather than explicit methods for capturing the true user preference when working with large media datasets. This means that the methodology used behind the scenes should not only be automated, but also non-intrusive for several reasons:

- In order to capture the true preference of a user, such a smart system needs to study the person's behavior through samples collected either through sequence of images or voice signals, without direct interference with the individual in order to avoid the collection of forced and obscured behavioral patterns. Therefore, in order to capture the true intention of any given person, the smart methodology should investigate them in a non-invasive way.

- The person should not directly type or talk to the system during the training process of learning the personal human behavior. Using a keyboard is the method currently used in many personalized services, but this doesn't fully solve the problem since it adds an additional layer of work with the system (the user is forced to type). This is also inconvenient for the fact that the person is forced to explicitly declare what the system needs to do, which defies the purpose of smart automation.

Having all of this in mind, it is easy to conclude that the machine should study the person before it makes a set of personalized settings to be applied later in a digital asset ecosystem. One such

way is through image recognition using signal processing techniques for identifying patterns in facial recognition, as well as gestures and body language. Another way is to capture voice and dissect it in couple of layers such as linguistic – and study what has been said, and prosodic – dealing with how the speech was produced by the user.

Essentially all of this will lead to the collection of behavioral characteristics, typical and fully descriptive of ones deduce and intent. Using implicitly collected features when applied to personalized data, collections can significantly enhance user's experience and interaction with any given ecosystem. If we collect samples from different signal streams namely image and speech, we can create behavioral sample for personalization in a matrix form or:

$$X_{Sp}^{HAFSN} = \begin{bmatrix} Y_{p1} & Y_{e1} & Y_{d1} \\ \vdots & \vdots & \vdots \\ Y_{p120} & Y_{e120} & Y_{d120} \end{bmatrix}, \quad (1)$$

Each of the rows in the *X* matrix in eq. (1), as determined in [10], represents a different feature in feature space directly taken from the speech signal and is denoted by *Y* in this case. When we study the collected datasets more closely we can determine boundaries of different behavioral patterns and set upper and lower limits for each one in vector form, such as:

$$Y^{HAFSN}\{\min_{y} a \div \max_{y} b\}, \quad (2)$$

where, *a* and *b* are the boundary conditions set for a cluster of human behavior, *y* lays between *a* and *b* for a continuous random vector of values for the feature variable *Y*, and *HAFSN* are the proposed emotional states *happy, angry, fear, sad* and *neutral* respectively as stated in [10]. We can then compute the probability of certain behavioral dependency for *Y* that can be present by calculating the probability density function (PDF):

$$\int_a^b f(y)dy, \quad (3)$$

where, *a* and *b* are the boundary conditions for each individual mood, as already established and *y* is a value from the set of extracted features *Y*. In order for this PDF to be valid, the following conditions have to also be satisfied:

$$f(y) \geq 0 \; for \; \forall \, y, \text{ and } \int_{-\infty}^{\infty} f(y)dy = 1$$

In other words, we set the condition in which, the PDF can determine the probability that *Y* lays between *a* and *b* for each emotion. This is the same as writing:

$$P(a \leq Y \leq b), \quad (4)$$

This entire process is valid for all features collected from the feature space for both feature domains: image and speech. When we gather all the available data and perform calculations in this order, we can create matrixes containing feature vectors of specific human behavior that will help train a system using efficient classifiers through machine learning techniques. As a result, the learning process of humans interacting with the digital cultural ecosystem will vastly improve and will inevitably lead to better user experience.

6. CONCLUSIONS

Some initial experiments with the presented learning analysis are done during the SINUS project [17]. Current and future research work will concentrate on the improvement of the presented learning analysis issues during the ongoing project "Concepts and Models for Innovation Ecosystems of Digital Cultural Assets", which aim is to develop optimal and feasible conceptual models and methods of analysis, understanding, interpretation, context-dependent use and sharing of content in ecosystems for digital culture in new ways and through innovative means for fuller delivery of knowledge to digital collections and archives of cultural artefacts [9].

The task we set at the beginning of this work was to propose a novel approach to dealing with the selection of content in a large data ecosystems consisting of specific cultural media assets. One of the issues was to create specific labels in the signals containing human sentiment information and train a system so that it can detect emotions with great confidence in order to create a practical automated solution for the task at hand. It was found that the proposed signal processing analysis technique was relevant to the research of enhancing the user experience when it comes to narrowing down the choice of media assets as it pertains to digital cultural ecosystems in our case. This methodology can therefore be applied to other sets of media content as it comes available.

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