The Use of Mixed-Realities Techniques for the Representation of Islamic Cultural Heritage

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Abstract—Left in the wake of cataclysmic change are the knowledge creation and holding structure of the past. Information knowledge and culture are central to human freedom and human development. How they are produced and exchanged in our society critically affects the way we see the state of the world as it is and might be. In recent years Mixed Reality (MR) has emerged as an area of extreme interest for visualizing and interacting with three-dimensional (3D) information in context, set in a story that reinforces learning and understanding of the cultural content. A commonly used and very inclusive definition of MR is that of all applications between pure Virtual Reality and the real world. How can we provide an intuitive user-friendly application for cultural heritage, which blends virtual imagery with the actual world, where users operate and interact with the information? How effectively can historical information and visual interpretations of the past be disseminated through such technologies? 'Tangible Pasts' consists of cultural domain expressing and analyzing the intended meaning of the shared vocabulary of concepts and relations in a domain of knowledge containing hierarchical classification systems and structured vocabularies with rich inter-linking of conceptual 'trees' i.e.: an object-oriented conceptual KC "Knowledge Cube", which combines audio-visual information and three dimensional models and animations. Modern cultural heritage exhibitions have evolved from static exhibitions to dynamic and challenging multimedia explorations. The main goal of visualization is to bring understanding of data. The task is to present complex information in the most comprehensive manner. Considering architectural artefacts, the visualization process is mostly focused on the understanding of spatial relations and on the recognition of particular style and form, letting users see characters and events in the past. This paper describes a storytelling-driven framework for Islamic Cultural Heritage representation that supports a new communication strategy able to combine content belonging to different cultural archives and accessed through an ontology-based integration and discovery mechanism, and fosters new data sharing and distribution policies that preserve the intellectual property rights of the involved institutions.

Keywords— cultural heritage; Islamic civilization; Islamic architecture; cultural tourism; augmented reality

I. INTRODUCTION

Modern cultural heritage exhibitions have evolved from static exhibitions to dynamic and challenging multimedia explorations. In recent years Mixed Reality (MR) has emerged as an area of extreme interest for visualizing and interacting with three-dimensional (3D) information in context, while the cost of building suitable MR applications has fallen considerably. Mixed reality interfaces, interaction techniques and devices are developing at a rapid pace and offer many advantages over traditional windows style interfaces. Virtual means "existing or resulting in essence or effect though not in actual fact, form, or name."

Mixed reality—a mix of augmented and virtual realities—differs from virtual reality by providing physical representations of people, places and things in a virtual world. In mixed reality, people can map out an environment or manipulate digital content in a way that virtual reality—despite being an immersive experience—cannot. [1]

In recent years Mixed Reality (MR) has emerged as an area of extreme interest for visualizing and interacting with three-dimensional (3D) information in context expressing the ability of digital storytelling to produce multi-vocal representations of cultural and architectural contexts. MR-based techniques, which superimpose such virtual models onto real-world scenes, can provide a promising presentation of architectural heritage. Virtual objects are occasionally superimposed onto the real world in real-time taking into consideration all aspects of digital cultural heritage ranging from tangible (books, newspapers, images, drawings, manuscripts, fashions, maps, artefacts, archaeological sites, monuments) to intangible content (e.g., music, performing arts, folklore) as well as the respective inter-relationships (e.g., visualizing buildings along with humans activities taking place in them).

II. PROPOSED METHODOLOGY

Virtualization of the history of Islamic cultural heritage means to actualize the heritage contents digitally and to simulate it using computer graphics technology. The features of "virtual heritage" include facilitating synthesis, conservation, reproduction, representation, digital reprocessing, and displaying cultural heritage using the advancements of VR technologies. One of the most powerful areas in the Virtual Reality (VR) field is that related to the systems designed to augment the user's view of the real world by embedding additional visual information, graphics and text: this area of research is called Augmented Reality (AR). This is a

combination of a virtual scene, generated by a computer, in which virtual objects are coherently integrated in order to complete the view of the real world. Mixing VR technologies with the real-world is referred to as "Mixed Reality" (MR). A Mixed Reality system merges the real world and virtual worlds to produce a new environment wherein physical and digital objects co-exist and interact *"Fig. 1,"*. The virtualization of the history of Islamic cultural heritage is considered to be a fundamental aspect for the full understanding of the historical and social development of that community and also forms a 'virtual material witness' for the process of civilization. By selecting an object of interest for example a cultural building in a certain location; a virtual walkthrough could be started. Scenarios could be created to demonstrate social applications with real-time multimedia processing and semantic enrichment of multimedia materials. These scenarios could also work with mobile technologies for semantically enriching search and retrieval; and re-contextualization of multimedia artefacts in knowledge intensive collaboration processes like storytelling. This visual system can have great potential for research, learning and for cultural tourism, and can also be a first step towards understanding possible innovative future applications in knowledge-based mixed-realities representation. This process could also assist to bridge the gap between recreation, education and scientific research.

Every society in history has faced the problem of shaping the environment it inhabited. Some rose magnificently to the occasion and produced works which rank among the fine arts. Many more produced less sophisticated but completely livable and enjoyable country sides, villages, towns, and cities. Creative diversity in culture and in the built environment can be seen as a result of the development of a range of strong and specific local identities, grown over centuries of continuous interaction between man's inner vision and his evolving natural and cultural environment. The growth of cultural identities in old Islamic cities was not a gratuitous process. It depended on man's existential experience of human values and on his ability to actively practice and realize his beliefs. The value of historic cities resides in the complexity of their structures, which are impregnated with the record of life and of human thoughts and activities: the whole is much greater than the sum of the parts.

Fig. 1. Knowledge visulization through intensive and integrated process.

III. VISUALIZING DIGITAL HERITAGE

We are using virtual storytelling through an AR demonstrator app to bring history back to life in an enjoyable and interactive manner. The main goal of visualization is to bring understanding of data. The task is to present complex information in the most comprehensive manner. Considering architectural artefacts, the visualization process is mostly focused on the understanding of spatial relations and on the recognition of particular style and form. The most natural way to convey this information is to build a three dimensional model. The construction should be seen as an intentional activity based on thoughtful well informed and inventive decision-making. [2]
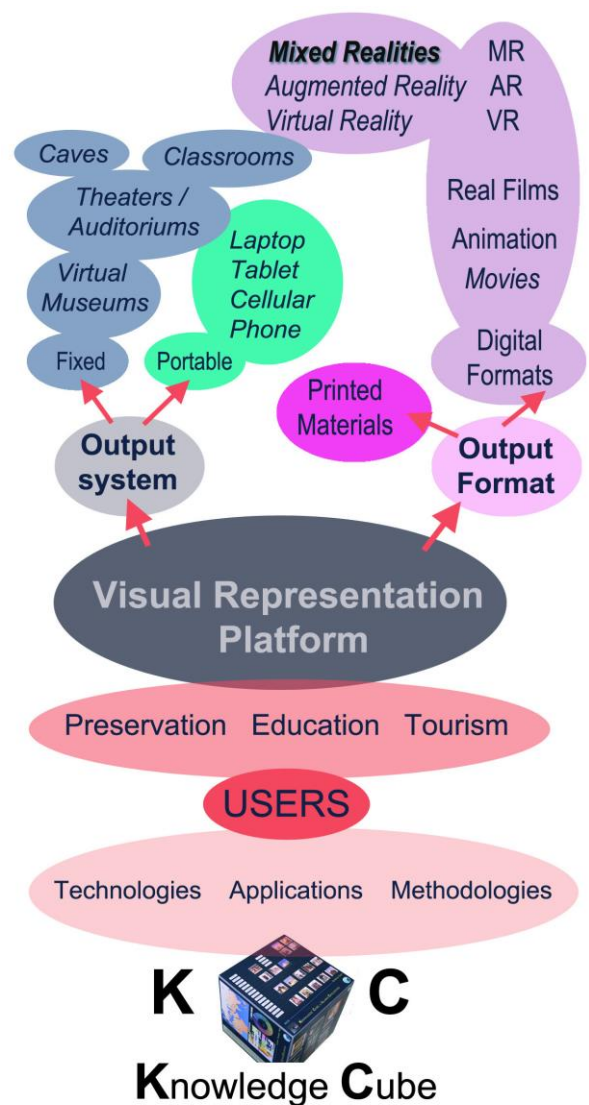
Such construction is best seen as the construction of meaningful forms and experiences close to the real world impressions. A multimodal mixed reality interface can be exploited to provide several different and interesting types of virtual heritage exhibitions. We can offer much more interesting interactive scenarios for viewing their digital collections (virtual reconstructions of their actual artifacts). The proposed multimodal mixed reality interface allows users to select the best visualization mode for a particular application scenario, and how images sampled from areas within photographs or paintings could be used as textures in the target VR scenario.

The integration of heritage with digital technology has already shown the potential for greatly enhancing many aspects of the research, management, and public involvement in the material remains of the past.

Fig. 2. A storytelling-driven framework for CH dissemination that supports a new communication strategy able to combine content belonging to different cultural archives.

Historic sites reflect both physical tangible heritage values and intangible values related to regional building styles and traditions, ways of living, sense of place and a multitude of cultural assets. [3]

The digital storytelling framework proposed in this paper aims at supporting different type of storytellers in creating stories. The proposed framework is designed with the aim of evolving stories that conventionally are authored and experienced as linear chronological structures, in interactive experiences enabling actions in a nonlinear and unpredictable fashion. The stories are created by using narrative structures based on the use of directed graph in which patterns of information represent the main elements of the story, whereas the edges and the related sequence of patterns of information represent the narrative flow of the storytelling. The goal of storytelling thus becomes the one of disseminating integrated cultural heritage, enhancing and promoting the cultural knowledge itself instead the single museum collections.

The implementation of these immersive and multimedia solutions may work toward filling the gap of traditional museums which are unable to offer adequate interactive stages for visitors and artifacts. By adopting affordable devices for VR and AR that are currently available on the market museums will have the possibility to exploit storytelling strategies for providing visitors with exciting immersive and articulated experiences, avoiding the problem to offer innovative technology but with very poor and uncared content.

The digital storytelling framework is designed around a graph based content representation that is the key for creating attractive and engaging multimedia narratives that can be easily transformed in real experiences personalized according to the user's profile, interests and context of use. An implementation of this framework was carried out in a context of a project focusing on information integration and access for a community of CH professionals in order to develop a comprehensive information system for Islamic cultural heritage. The proposed solution aimed at defining a semantic mechanism for retrieving data from a variety of knowledge sources through a well-defined ontology. The ontology was used both for integrating museum databases and for proving a knowledge representation of a given Islamic CH. In this context, the ontology was designed on the base of the standard reference model for CH—the Knowledge Cube. The Knowledge Cube ontology represents a suitable basis for a common CH description language and for supporting conceptual modelling activities in each cultural context. The approach, built upon KC, is based on an ontology layer that focuses on interoperability of information systems and databases and abstractly defines concepts and relationships. This research will use the taxonomy development method to track interactive and integrated elements of Islamic cultural heritage. Taxonomy is the classification scheme or system – it provides a structure and an organization to the knowledge of a field; moreover, it aims to identify a set of dimensions each containing a set of characteristics that describes the objects in a particular domain *"Fig. 2,"*.

Through the use of a Narration Builder tool, we can write stories according to the historical, artistic and anthropological

meanings they want to disseminate. The process of specifying a story consists in three main phases:

A. Search relevant objects:

By making use of the KC, the archaeologist searches the artefacts which are relevant for the narrative. Relevant information can directly retrieved from the databases, e.g., I want to specify a narration of where, when, and how Alhambra in Granada was built, and what kind of activities was going on there.

B. Select relevant objects or concepts:

Among the information retrieved from querying the data sources, the next phase is to select the data the story will be linked to.
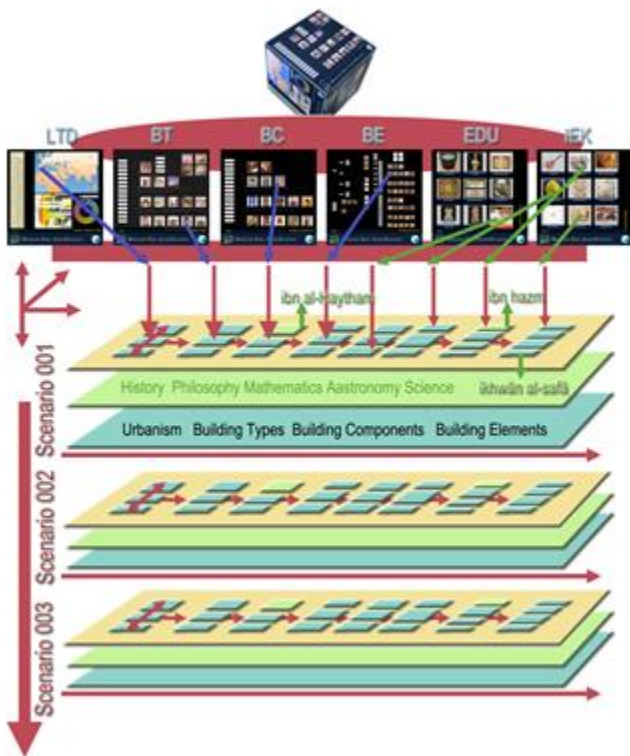

Fig. 3. KC consists of layers of Information and Knowledge.

C. Specify the story text.

The last phase is the specification of the narrative. The stories are stored in the ontology itself; the authors can access them to revise the text or change the associated objects or keywords. *"Fig. 2,"* represents an example of instantiation of the storytelling-driven framework proposed in this paper.

IV. MIXED REALITIES AND KNOWLEDGE DISCOVERY

Digital technologies offer new modern tools for cultural heritage preservation; they also play a leading role about key issues as providing access, interaction and sharing knowledge.

It is an excellent way of transmitting knowledge while playing at acting (users play the role of a king on the throne). This mechanism operates in information transferring, taking on a specific didactic form that presents very positive results. In addition, motivated by the installation, the user makes a significant commitment that is unparalleled in a multimedia application existing only for informative purposes *"Fig. 3,"*.

Through the use of the ontology-driven data access, the composition layer supports the community of domain experts in creating stories. By using a Storytelling Editor, the author can retrieve relevant material (texts, images, video, and other stories) to use in composing the narrative. This information discovery mechanism does not search the actual objects in the collections, but uses the descriptive metadata of the objects. The metadata are part of the ontology used for modeling the concepts and relations of the knowledge base composed by archives integrated at the data layer. These metadata are also used for describing the content of the stories (e.g., themes and sub-themes). By using a layer structure, the Storytelling Editor helps domain experts in creating stories. The story structure is created by using a directed graph in which patterns of information represent the main elements of the story, and the edges and the related sequence of patterns of information represent the narrative flow of the storytelling. The graph is structured in such a way that from a patterns of information it is possible to move to another patterns of information by following different storytelling paths. Structures can be newly created, selected, adapted or merged by using the graph operations.

For each pattern of information, the author has to define its characteristics and the related multimedia content, that is, the combination of images, sounds, videos, animations and/or texts that represent an element of the story. For each multimedia item, the author can provide different versions, for example, images at different quality, texts suitable for different purpose (e.g., short text for a brief overview or long in-depth text), and animations accessible via Web or by using VR/AR devices. Existing multimedia items are retrieved by the system via the ontology-driven data access service according to the keywords associated with the story structure. [2]

In order to do this, we can explore a variety of methods to both create and deliver virtual content. This is a conscious strategy designed to maximize access to the data and results for other researchers and the broader public. As an engaged project, this approach balances the requests of descendants with the demands of academic consistency. Heritage is as much about the living and evolving place, environment, people, static monuments and landscapes. Virtual environments which are culturally embedded are often classified as virtual heritage. Generally, cultural heritage and virtual heritage have independent meanings.

Since antiquity, images were used as records of both events-lifestyles, as well as decorations. The possibility of

reviving them will add a new dimension in understanding our past. Potentially a Virtual Reality-based heritage experience gives the visitor die opportunity to feel they are present at significant places and times in the past and use a variety of senses to experience what it would have felt like to be there. Virtual heritage makes the interpretations of history more accessible to the general public, and at the same time narrow the individual's scope for personalized, interactive experience and visualization of the description of it *"Fig. 4"*.

Virtual heritage also attracts more people to cultural heritage sites and boost investment in digital representation of cultural assets. This will enable the exploration of new ways to present cultural heritage information to people of different cultural backgrounds, and especially children. In this regard we can include Virtual Cultural facilities, in which participants can switch dynamically between virtual web-based environments to indoor augmented reality environments as well as make use of various multimodal interaction techniques to better explore heritage information in virtual museum for the world of Islamic Art, Architecture and Urbanism. The museum visitor can potentially experience their digital heritage in the physical sense in the museum, then explore further through the web, visualize this heritage in the round (3D on the web), take that 3D artefacts into the augmented reality domain (the real world) and explore it further using various multimodal interfaces. The system aims in educating the visitors about artefacts and their history*"Fig. 5"*. This project could develop 3D multimedia tools to record, reconstruct, encode and visualize archaeological ruins in virtual reality. These tools could be applied to buildings, building parts, pottery, terrain geometry, textures and texture materials. [4]
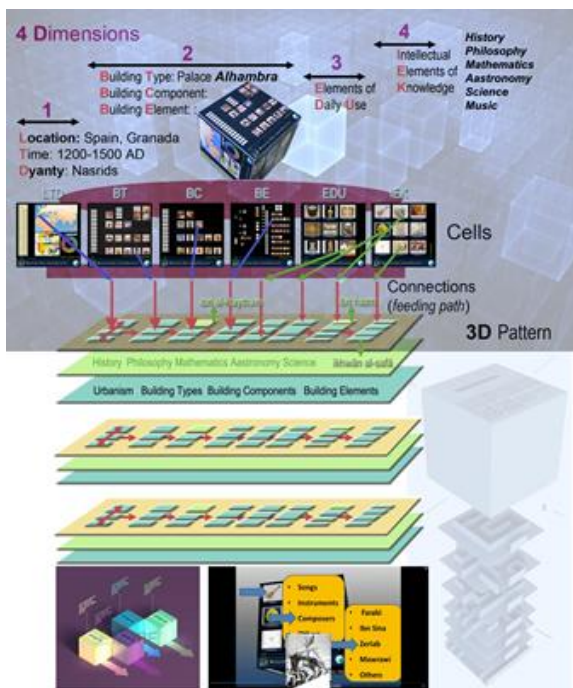

Fig. 4. Through this system the true and actual picture of actions and events that happened through Islamic civilization, could be represented to gain knowledge.
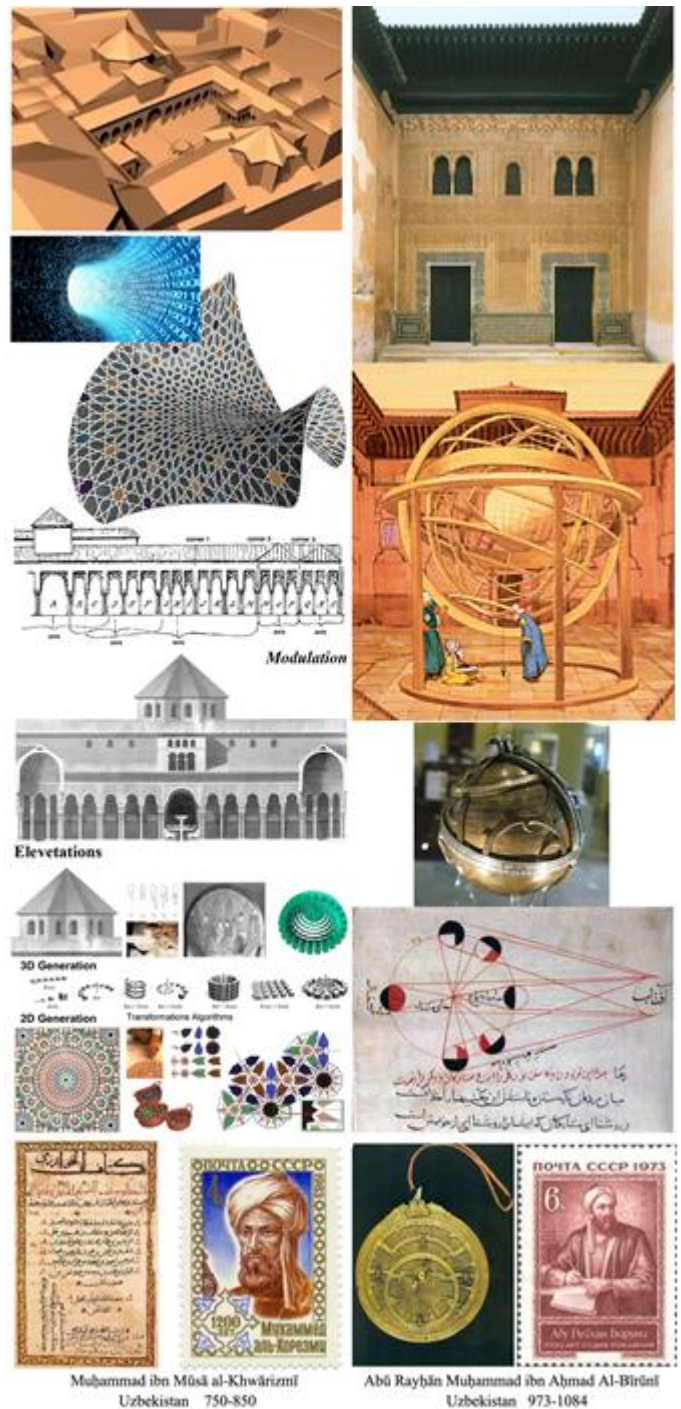

Fig. 5. The connection of different related aspects of civilization In an integrated story structures to give the true and real image of Islamic civilization.

Conferences and seminars, interesting dates and case-studies will be collected; and nice showcases dedicated to associations, artists and companies, provided with many information and amazing multimedia contents in every format will offer a wide overview about what's going on. Just as diverse as the applications are the technologies that have been or are currently being exploited to support the display of

information and interaction with it. These include smartphones, tablet computers, custom-built "museum kiosks", and so-called "immersive" Virtual, Augmented Reality and Mixed Reality (VR/AR/MxR) techniques – head-mounted displays, theatres and CAVEs "Cave Automatic Virtual Environments". The delivery of rich multisensory worlds to a technology hungry population of end users now exploits familiar media platforms, from "serious games".

Virtual heritage makes the interpretations of history more accessible to the general public, and at the same time narrow the individual's scope for personalized, interactive experience and visualization of the description of it.

Augmented reality involves three basic qualities; the mixing of real and virtual in three dimensions, in real-time, in a format inviting interaction between the users and content. In order to meet these requirements, the AR system requires a video input, a projection screen, knowledge of its location in reference to the virtual content to display, and access to the stored 3D models (either saved to local memory or delivered over the internet). The AR approach also removes the need to have separate controls for looking at things, and it filters out the distractions of the real world. About the user experience, it is important to underline that the user is able to look around completely naturally, without using any controls. It is an intuitive approach to discover the hidden story of a fragment of cultural heritage.

Islamic Architecture in the information age can have the capabilities of adaptation, and development through two main strategic channels. First, through an analytic documentation for the urban and architectural heritage, secondly, through a futuristic methodologies of Knowledge integration and accessibility that are especially adapted for Islamic art, architecture and urbanism which forms the container of the tangible and intangible elements of Islamic civilization

Here rises a question on the ability of historic cities to become a source of inspiration which enables a society to innovate by re-interpreting the past, overcoming the dichotomies resulting from a single-minded pursuit of a narrow vision of "progress"? Can a creative exploration and a careful evolution of historic structures give birth to cultural processes which re-establish an organic link with the past- not for the sake nostalgia, but for the sake of re-integrating a human wholeness, drawing on other motivations than merely the rational?

Through strategic interventions with objects, geometry, video and sound, the proposed digital storytelling framework endeavors to generate queer affects, experiences of disorientation, and detours in syntax, as means of communicating embodied experiences of transcultural queerness. [5]

At the same time, the digital information and communications technologies (ICT) have produced a wide range of applications for collecting and processing historical

data, documenting and monitoring the physical conservation of objects and monuments, visualizing historic structures and environments, and creating interactive information networks that can link professionals and scholars with students, museum-goers, and interested amateurs.

V. CONCLUSION

A multimodal mixed reality interface can be exploited to provide several different and interesting types of virtual heritage exhibitions. The novelty of the technologies employed is that they allow users to switch between three different types of visualization environments including: the web in the traditional way, but including 3D, virtual reality and augmented reality (thus mixing these different formats into the same architecture). Additionally, several different interface techniques can be employed to make exploration of a Virtual Cultural Centre for Islamic Civilization in order to:

- Establish genuine inter—cultural dialogue at local, national, regional and international levels; and add much-needed light on the shared roots of Islamic and Western cultures and on the richness of their inextricably intertwined histories.

- Stimulate innovative approaches and tools to facilitate knowledge transfer in the field of cultural heritage.

- Networking and clustering of projects and research and reducing fragmentation of research efforts and promoting attention to sharing and exploiting knowledge from many varied sources.

- Introducing knowledge as a mental journey through which understanding is constructed as one which begins with the presentation and acquisition of data, moving the key stations of information and knowledge, and on towards wisdom and insight.

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