

The MEMEX project: MEMories and EXperiences for inclusive digital storytelling

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Abstract

MEMEX is an interdisciplinary H2020 European Project which promotes Artificial Intelligence as assistive technology. Its goal is to foster social cohesion, helping communities at risk of social exclusion to better integrate in society. The technological embodiment consists in the development of a smartphone application which allows individuals to express their stories and to associate them with items of cultural heritage in the city where they live. Such association happens by means of a knowledge graph which stores both information on cultural heritage and stories created by people, and models the connections between them with edges. Visualisation of the stories happens via augmented reality, strengthening the ties between the spaces of a city and the memories of people, fostering a sense of belonging.

1 Introduction

MEMEX is a three-year project funded by the European Union Horizon 2020 framework (<http://memexproject.eu/>). The MEMEX project promotes social cohesion through collaborative, heritage-related tools that provide inclusive access to tangible and intangible Cultural Heritage (CH) and, at the same time, facilitate encounters, discussions and interactions between communities at risk of social exclusion. These tools will empower communities of people with the possibility of welding together their fragmented experiences and memories into compelling and geolocalised storylines using new personalised digital content linked to the pre-existent European Cultural Heritage. The tools of MEMEX will allow the communities to tell their stories and to take part in the cultural life of the European society. To this end, MEMEX will nurture actions that contribute to, rather than undermine, practices of recognition of differences by giving voice to individuals for promoting cultural diversity.

The technological embodiment of MEMEX is an app installed on a smartphone allowing non-expert users to create and visualise stories related to their personal memories and experiences digitally linked to the geographical locations of either tangible cultural places/objects or intangible ones (e.g.



Figura 1: An example of the Augmented Reality visualisation of user-created stories, connected with an item of Cultural Heritage in urban environment. MEMEX aims at giving voice to socially fragile communities, allowing them to tell their stories and to connect them with the urban spaces where they live.

the location of an event). The interface, co-designed to embrace the needs of the community, allows users to annotate using Augmented Reality (AR) any physical object or location with their memories in the form of digital images, videos, audio recordings or textual input using a smartphone. The targeted communities are able to connect their experiences and memories with a new Knowledge Graph (KG), linking CH items and places with stories that are bound and entangled within the European history. Effectively, the participants of MEMEX are actively shaping contemporary and historical content, including new material from their experiences and memories, and personalising CH and creative media content in a meaningful and social inclusive manner (see Fig. 1 for an example of the visualisation of stories in AR).

The target communities of MEMEX are composed of socially fragile people who may be excluded from social and cultural opportunities in society, and which are fundamental for social integration. MEMEX is deploying three distinct pilots which provide a heterogeneous sample of such

communities, in order to analyse different expectations from communities located in different regions of the European territory:

- Migrant women in Barcelona (Spain);
- Communities from former Portuguese colonies in Europe (Portugal);
- Priority neighbourhood from Paris suburbs (France).

To a larger extent, the policies, procedures and technology of the collaborative tools developed in MEMEX will promote an innovative vision for creating digital stories that will reach different targets of stakeholders: curators of museums and galleries, creative industries, artists, educational institutions, etc.

2 Objectives and research themes

The interdisciplinary objectives of MEMEX have been divided into two groups: Social and Technology objectives. The success of the project is achieved by pursuing each of the six individual goals.

Social Objectives – MEMEX overall social goal is to encourage social cohesion by undertaking actions which implement best practices for social inclusion and strategies for audience engagement to promote recognition of differences, while additionally providing the EU with effective tools to combat social exclusion. The social goal will be achieved developing the following objectives:

S01 - Social analysis for communities need (MEMEX-NEED). The objective will indicate best practices to understand and study the causes of exclusion and pinpoint the resources that are not accessible to the communities. To this end, new benchmarking tools will be developed to assess the need of the community and their feedback will help to readjust the inclusion and cohesion strategies of MEMEX.

S02 - Guidelines to benchmark social inclusion (MEMEX-INC). Starting from the mapping given by MEMEX-NEED, the objective is to understand the best practices necessary for promoting inclusion and cohesion with collaborative, heritage-related tools given the specific cultural background of the at-risk communities and the causes for exclusion.

S03 - Design of new audience development strategies (MEMEX-DEV). The objective focuses on creating specific audience development strategies using the storytelling tools of MEMEX that can increase the number of people attending cultural events, diversify the audience, make easy the access to the app functionalities.

Technology Objectives – MEMEX overall technology goal is to create easy to use ICT tools for the communities at risk of exclusion and, at a larger extent, for European citizens to create and engage into stories linked to our cultural heritage. The tool will be shaped over the user needs and it will allow to collaboration in the input of content and in the creative process of storytelling. The technology goal will be achieved developing the following objectives:

TO1 - Geolocalised annotation of CH assets (MEMEX-LOC). The objective is to develop a new software infrastructure running on consumer smartphones for annotating physical heritage objects or places with the users knowledge

and memories. The information will be as well geolocalised on a world map, providing readily accessible information of heritage and community stories.

TO2 - New Knowledge Graph infrastructure for semi-automatic storytelling (MEMEX-KG). The objective is to create a novel KG and associated retrieval tools to be used in the geolocalised storytelling engine of MEMEX. The information provided by each user is ingested in the KG that can link together verified information provided by cultural institutions to the community knowledge and memories.

TO3 - Co-design of compelling storytelling with AR on smartphones (MEMEX-TELL). The objective is to create a compelling AR experience using a smartphone both for creating and engaging geolocalised stories. The tool has to be usable by any users and in any environment. For this reason, a co-design approach will implement updated requirements arriving from tests on the field made in the three pilots of the project.

3 Consortium

The MEMEX consortium draws its partners and the third parties involved in the project from six countries in the geographical European area, including Italy, Spain, Portugal, France, Ireland and Belgium as EU Member States. The project has a highly interdisciplinary component crossing the social sciences, (digital) humanities, computer vision, augmented reality and machine learning, to name only a few. The consortium partners have been carefully chosen to have specific, independent and complementary skills essential to fulfil MEMEX's objectives. The remainder of this section briefly presents the partners and the role they have in the project.

Italian Institute of Technology (IIT, Italy) – IIT is a scientific research center established by Italian Ministry of Education, University and Research and Ministry of Economy and Finance, in order to promote excellence in both basic and applied research and to facilitate the economic development at national level. IIT acts as coordinator of the project and provides innovative technology for linking the CH digital assets to the physical world. Using computer vision and dynamic clustering, the team will provide a new combination of technology to find objects in repositories and link them to CH digital data. Moreover, IIT implements the technology for clustering CH digital assets as stored in the KG for effective user friendly storytelling. The people involved in the MEMEX project at IIT are: Alessio Del Bue (PI, project coordinator), Stuart James (researcher, assistant professor), Matteo Taiana (post-doctoral researcher), Matteo Toso (post-doctoral researcher) and Muhammad Sarim Mehdi (technician)

Interactive Technologies Institute (ITI, Portugal) – ITI is part of the Associated Laboratories of Robotics Systems (LARSyS). It operates in the interdisciplinary domain of Human-Computer Interaction (HCI), encapsulating contributions from the disciplines of computer science, psychology, social sciences and design. This placement allows ITI to design and develop computing technologies that match with human capabilities, taking into account the needs and desires of users and other stakeholders, and economical, cultural and social constraints. Contributions to the project focus

on development, deployment and evaluation of technology interventions for public use, engagement and awareness in participatory culture in which private individuals act both as consumers and producers.

NOHO Limited (NOHO, Ireland) – Noho are specialist producers of captivating digital experiences for the cultural heritage sector with a strong emphasis on narrative design. They bring to the project their experience in digital interactive media and user experience design, including design and production of multimedia (2D and 3D) assets, engaging visualisations using animation and real-time 3D or immersive, interactive applications and environments (Augmented Reality, Virtual Reality).

EY Advisory SpA (EY, Italy) – EY is a global leader in advisory, assurance, tax, transaction services, with a presence in over 140 countries. Leveraging on its expertise, EY is developing the MEMEX app, vertically contributing to the activities related with APIs development to allow for interaction with the KG, large scale indoor and outdoor AR visualisation development, and transversally contributing and leading the activities related with innovation management, including the definition of the Exploitation Plan for MEMEX.

Centre National de la Recherche Scientifique (CNRS, France) – CNRS is among the world's leading research institutions. Its scientists explore the living world, matter, the Universe, and the functioning of human societies in order to meet the major challenges of today and tomorrow. In the context of the project, CNRS provides its expertise in SLAM systems for real-time 3D reconstruction of both indoor and outdoor environments. The technology proposed uses videos from monocular and stereo cameras, feature computation, 3D camera pose estimation, sparse and dense 3D reconstruction to obtain an immediate 3D representation of the area. Moreover, the approaches being developed will be robust to dynamic objects, filtering out moving pedestrians, cars and other objects not useful for camera relocalisation.

Association of Instituto Superior Técnico for Research and Development (IST-ID, Portugal) – Instituto Superior Técnico is the largest and most reputed school of Engineering, Science and Technology in Portugal. IST-ID is a private not-for-profit institution, which aims at carrying out Science and Technology activities and fostering knowledge transfer for the research units of IST. IST-ID possesses a strong multidisciplinary background, including art, design, social sciences and engineering. This combination of fields allows for a deeper understanding of the impact of emerging technologies can have in contemporary life. IST-ID's contributions to the project focus on the design and evaluation of the interaction between the people and the MEMEX app, considering how the interaction fulfills the needs of people at risk of social exclusion, both as creators and consumers of content.

Centro Europeo per l'Organizzazione e il Management Culturale (ECCOM, Italy) – ECCOM is an organization created with the aim of promoting an interdisciplinary approach to the cultural and creative sector. ECCOM carries out analyses, research and training projects for public and private commercial administrations. Its activities cover different thematic areas, including Audience engagement and Audience development, Cultural heritage and community empower-

ment, and Social inclusion. Within the MEMEX project, ECCOM cooperates in the planning and implementation phases of the pilot studies, in the definition and evaluation of the audience development activities, in the impact assessment of the social impacts of the project and in the communication and dissemination phase.

University Ca' Foscari di Venezia (UNIVE, Italy) – Università Ca' Foscari Venezia is a leading university in Italy in Economics and Management, Humanities, Languages and Literature, and Science. The European Centre for Living Technology, founded at Università Ca' Foscari Venezia, is linked with 17 European research centres, and is devoted to the study of technologies exhibiting life-like properties such as self-organization, adaptability and capacity to evolve. In the context of MEMEX, UNIVE contribute focuses mostly on the development of the MEMEX-KG module with tasks related to cultural heritage digital assets data preparation and to the clustering algorithms necessary for linking CH objects to user input and accessing the Knowledge Graph.

Michael Culture Association (MCA, Belgium) – MCA is a not-for-profit organisation devoted to European cultural heritage valorization by its digitization and dissemination to a European and worldwide audience. It gathers members and experts from over 150 cultural institutions both private and public. MCA has a strong experience in EU funded projects and mainly in Digital Cultural Heritage: its aggregation, its preservation, its valorisation and re-use, including for Digital Story Telling. Its focus on the project is on communication and dissemination, along with designing and managing the French pilot study, in collaboration with Dédale.

Dédale (DED, France) – DED is a French research and production non-profit agency dedicated to urban and social innovation. Its expertise lies especially in the fields of urban planning and policies, Smart Cities, culture and media, sustainable development, and citizen Empowerment. Its key activities are assistance and consulting for public authorities and European institutions, urban planning for local authorities and urban developers. In the project, the main focus of DED is on designing and managing the French pilot study, located in Paris.

Fundacio Interarts per a la Cooperacio Cultural Internacional (IA, Spain) – IA is a non-governmental organization based in Barcelona, Spain, which promotes the value of culture and cultural policies for sustainable human development and actively advocates for the inclusion of culture in local and international development agendas. It coordinates international cooperation projects linking culture to human rights, health, the economy, social inclusion, and migration. Since 1995, it took part in over 1.000 projects in 70 countries across three continents (Europe, Latin America and Africa). In the project, the main focus of IA is on designing and managing the Spanish pilot study, located in Barcelona.

Mapa das Ideias (MDI, Portugal) – MDI is a Portuguese privately-owned company dedicated to the relationship between museums, audiences and communities. From audience management and communication planning to educational services, from learning kits to exhibition design, over the years MDI acquired expertise while developing a variety of solutions. In the context of MEMEX, MDI focuses on organising

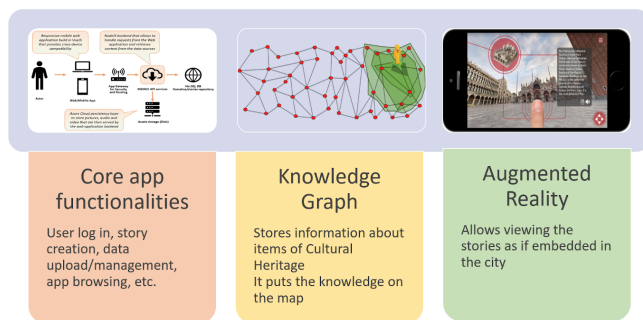


Figura 2: The MEMEX app is composed of three main parts: the core app, the Knowledge Graph and the Augmented Reality module.

and managing the Portuguese pilot study based in Lisbon, which deals with communities of first and second generation migrants and their relation to Portuguese heritage. Other tasks include performing heritage research and mapping, and working with social sector partners, to monitor the impact of the project in the communities, regarding their sense of belonging in the country and their technological literacy.

4 Technological aspects

The MEMEX smartphone application is composed of three main parts (see Fig. 2). The **core app** functionalities deal with creating, browsing and visualising the content of the stories in 2D. This requires storing and visualising the content the participants associate with their stories (text, images, audio, video), visualising information on the connectedness of stories and items of cultural heritage associated by analysing their inter-connectivity with the Knowledge Graph, and more.

The **Knowledge Graph** was implemented using the NEO4J [neo,] graph database software. Our bespoke KG contains nodes of different types: "place" nodes are related to items of CH with a physical location ,e.g., a statue, while "knowledge" nodes are related to intangible knowledge, e.g., one architectural style. "Story" nodes contain information on stories created by the participants, while "journey" nodes are used to represent ordered sets of stories. A custom ingestion tool has been developed to handle CH data from heterogeneous sources (Wikidata [wik,], Europeana [eur,] and Mapillary [map,]) and was used to collect information on CH items located in the cities of the pilot studies (Lisbon, Paris and Barcelona). Given Wikidata's large size and the need for geolocalised content, we used a two-step process to select relevant content: the first step consisted in downloading all tangible CH items present in the areas of interest, while the second consisted in crawling the sources of data for intangible CH connected with the previously downloaded tangible CH items. In practice, for Wikidata, we limited the distance between tangible and intangible nodes to three hops. The KG runs on a server and can be queried by the smartphone app via an API. Both the textual content of stories and of CH nodes are encoded using Word2Vec and are grouped using Dominant Set clustering.

For the **Augmented Reality** functionalities, the app needs to model objects in 3D, so that is possible to visualise content



Figura 3: Screenshot of the MEMEX app after the successful creation of an ellipsoid modeling a statue in Lisbon, Portugal.

provided by the participants as associated to one modelled object in the scene. We decided to model each object using a simple geometrical shape: one ellipsoid. The ellipsoid is a convenient shape because it can be estimated from a small number of views, while still retaining information on the location of one object, as well as coarse information on its size and orientation. For estimating object ellipsoids using a smartphone, we developed a system in which a SLAM component is executed on the phone (ARCore [arc,]), while a set of algorithms runs on a remote server. The server executes one object detector on the images received from the phone, followed by a tracker. Then, the tracks are processed by the Localisation from Detection (LfD) algorithm [Rubino *et al.*, 2017], which produces one ellipsoid for each track. Finally, the resulting ellipsoids are sent to the phone for AR visualisation (see Fig. 3 for one example). When creating ellipsoids for common objects, an off-the-shelf tracker can be used, while for CH objects we currently require the person using the phone to draw a circle on the object of interest, as it is seen from three different points of view. An ellipsoid generated on an item of CH is associated with the correct node in the KG by means of a constrained retrieval algorithm, based on the smartphone GPS location and on image similarity. The AR experience persistence is ensured by employing "Cloud Anchors", a framework that allows storing the local 3D representation built by the ARCore SLAM module on a server, and to retrieve it at a later time.

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