AN INTERACTIVE MODELLING ARCHITECTURE FOR EDUCATION AND ENTERTAINMENT AT MUSEUMS

Andrés A. Navarro-Newball[1], Isidro Moreno-Sánchez[2], Ali Arya[3], Edmond C.Prakash[4], Efetobore Mike-Ifeta[3], Juan D Mejia-Mena[1]

[1]Pontificia Universidad Javeriana (Colombia)
[2]Universidad Complutense de Madrid (España)
[3]Carleton University (Canada)
[4]University of Westminster (UK)

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1. INTRODUCTION

The social role of museums has changed dramatically in the last decade while communication and design rationales are still catching up [1]. Museums no longer fit the early modernist model of the nineteenth century museum, with its authoritative narratives; many now offer interactive and open-ended experiences [2]. Interactivity is therefore sought after and becomes desirable in this domain because of the immense benefits it has contributed to the furtherance of engagement in other fields. Museums give visitors the opportunity to connect concepts to objects and concrete situations [3]. Traditionally, visitors see objects exposed behind a glass and often they live a no causative experience. Our Interactive Model for Museums (MOMU) aims to support complex cultural contents in museums using tools that favour learning and user's entertainment.

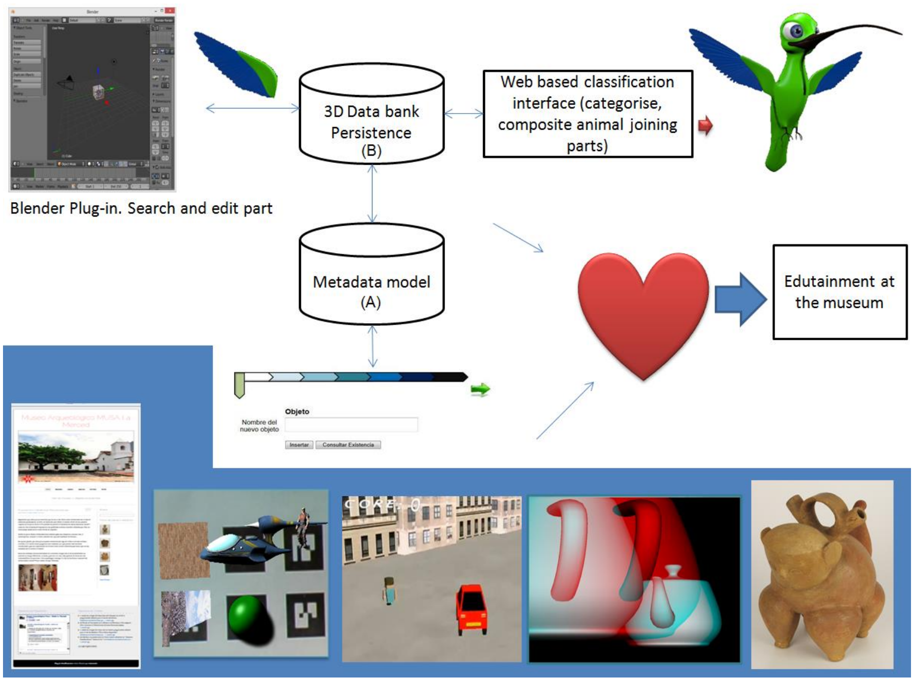

Fig. 1. System architecture. The content management system (A) relates real objects, documents, virtual models (B) and interactive technologies (blue region) to create an edutainment experience at the museum.

Technology elevates interest and allows creating experiences that transform the visitors [4]. However, technology at museums usually lacks of a methodology that integrates it in the general speech and of a methodology that achieves unity of all interactive systems with each other; technological developments at museums are sometimes intrusive [5] or rigid [6]. MOMU's aim is to provide tools to create edutainment experiences at museums by enhancing flexibility, while staying independent of the technology used and taking care of not being disruptive with exhibition objects at the museum. Our approach is closer to the one described by White et.al. [7], the main differences are:

- MOMU will be able to provide content to in-site, virtual, mobile and physical experiences.
- The basic concepts underlying the research are (1) a new approach to the museum experience as a customizable interactive narrative, where a curator proposes a narrative and the visitor affects it creating his\her own story (2) a social context within which that experience is implemented, and (3) the use of various interactive technologies to facilitate the experience.
- The choice of the technology used will be in hands of the user of the system. For example, a high school teacher will decide in which way he/she wants to present a particular concept.
- One big challenge is to propose a computational model to allow representation and introduction of cognitive tasks to exhibitions. In the high school teacher example, he/ she needs to achieve particular educational objectives in the tour. For instance he/ she will be able to relate not only technology and concepts but also cognitive tasks.
- We propose the creation of tools to facilitate 3D content creation and classification that will provide virtual models for inclusion in required virtual scenarios.

2. TOOLS AND METHODS

The development of the project have required visitors and exhibition observation, including a study on visitors on different museums in the world, including exhibitions with and without technology. A sample of museums has been used that reflects the diversity of contemporary museography as far as thematic (e.g. art, sciences, archaeology, history), to location (Colombia, Spain, Canada, United Kingdom, France) and to types of museography (e.g. interactive, digital, non-digital). Our interdisciplinary methodology considers Cognitive Analysis of Tasks (CAT) within the study of innovative problems and solutions. This is a major difference from other approaches which looks forward to assure that the tools implemented within the model deliver educational content according to museum needs and visitors' interests [8].

Our model (Figure 1A) will allow the introduction of objects to the museum's collection and the introduction of new collections. This will be the starting point for a user wanting to create a learning and joyful experience. The data bank must store narrative, information and documents associated to objects and collections. MOMU provides a 3D creation tool (Figure 1B). The tool includes a 3D data bank and editors to ease the construction of virtual characters required in the development of 3D interactive environments. This will be a second step for a user wanting to create an experience. Once he/she recognises the need of virtual models, he/she can search on the graphics data bank for readymade models. Then, interaction technologies must be associated with objects, and collections. A set of input technologies (from left to right, blue background region in Figure 1) that can include Web 2.0 (social media), augmented reality (AR), video games, virtual reality and real museum's objects facilitate interaction.

The heart of the system allows the creation of experiences according to needs (obtained from observation). It is still under development and requires: (1) the enhancement of the current model in a way it naturally integrates different technologies and assets; (2) the computational representation of cognitive principles to be associated with real objects, collections and tours; (3) a way to include time dependent information to enhance narrative; (4) an interface to allow the creation of learning and joyful experiences minimising programming and promoting content reuse.

For visitors, the proposed system will function in three major capacities, planning, guidance, and the provision of social media capability. The proposed system is divided into three tiers corresponding to the three functions. The first tier will cater to trip planning, acting primarily as the first experience for the user. It will be available online, on mobile devices, and also on location through specific kiosks, while the plans will be saved in user profile and will be accessed and edited at any time and through any device. The second tier lends itself to guidance and way finding. This tier is a combination of AR, display centres and the use of physical spaces such as floors, walls for navigation. The display centres, stationed at key spots in the museum will be an extension of the first tier. Such integration of planning and guidance will also allow the users to add items such as photos, tags, and comments to their itinerary as they follow it. The final tier opens up to social media and provides the user with the ability to connect and interact with other visitors.

3. AFFORDABLE INTERACTION TECHNOLOGIES

It is possible that interaction gadgets at museums get broken or lost. Additionally, they cannot be taken home for further interaction. Thus, a possible solution can include pieces of paper, a floor and touch-less or contact-less devices which cannot be easily broken and a "take home" paper brochure. We propose AR books as an inexpensive mobile interface based on paper; Microsoft's Kinect as a touch less device bringing tangible properties to several surfaces and affordable tracking options to virtual reality (VR) and; the museum's floor as the ultimate resistant interaction device. Affordable interaction technologies will be beneficial for low income museums, having the potential to attract and entertain while keeping costs low.

A tangible interface allows user interaction with digital information through the physical information. "Tangibles, in the form of physical artefacts embedded with sensor technologies, offer the opportunity to exploit and build on our everyday interaction and experience with the world, enabling new forms of engagement and access to tools for supporting learning" [9, p.151]. AR "offers an innovative learning space by merging digital learning materials into the format of media with tools or objects, which are direct parts of the physical space, therefore creating situated learning" [10].

AR books enhance the reading experience, visualise products, tell stories and teach. They can provide other views of complex situations, increasing understanding and are an evolution of traditional books, the main medium of teaching and learning [11]. The Magic Book [12] explored transitional interfaces between physical reality, AR and VR. It could be read without technology; images were overlaid with a handheld display which let viewing scenes from any perspective or; it was possible to fly into the scenes to have an immersive VR experience as life sized virtual avatars. This book offered only selective viewing from different perspectives and 3D content was added from content scripts. Traditionally, AR book creation have had difficulties such as relying on software configuration or scripting, requiring real pages or complex registration of new markers, [11].

With our AR book, we have been able to overcome some of the difficulties from previous AR books: (1) include all major data types such as 2D static; 2D dynamic; 3D content and sound (Figures 2A and B). (2) offer an authoring interface using dialog boxes; (3) create authoring tools to create pages and to introduce markers with related elements such as virtual models, animations, videos, sounds, images and gestures in order to create any book; (4) explore a novel way of interaction which integrates gestural interaction from the Kinect to the book, besides projecting 3D objects and animations with synchronised rotation and translation on pages. Thus, the novelty of our book relies on the flexibility provided to include major data types (many books focus on a subset of them), to create any book based on fiducial markers (many systems are developed for one single book), and to assign Kinect-based "take", "move" or "zoom" gestures to virtual objects displayed in every page (many books use additional AR cards for this).

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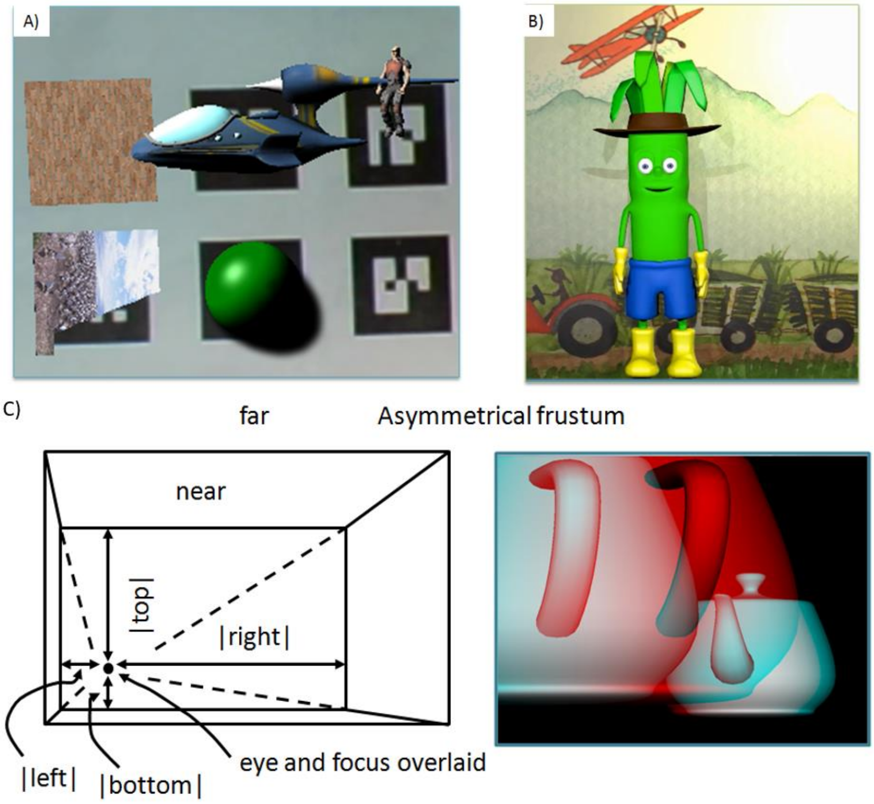

Fig. 2. AR Books and brochures. A) Augmented reality book page with markers displaying several multimedia types. B) AR demo for the sugar cane museum. C) Kinect and VR tracking using anaglyphs. With the Kinect sensor we are able to create an asymmetrical frustum to simulate real 3D perception.

Also, with the Kinect we provide integration to basic VR scenarios. The Kinect has been used in interactive environments proposing new forms of natural gestural interaction [13] that add third dimension and physical extensions to user interaction (Figure 2C). Our developments towards an interactive floor are explained in our previous work [14].

4. MODELLING TOOLS

This development was motivated by the need of creating 3D animals for virtual environments at museums and inspired by the modelling by parts approach [15] and by the idea which state: "from the first dawn of life, all organic beings are found to resemble each other in descending degrees, so that they can be classed in groups under groups" [16, Chapter 13]. Our model categorises a 3D component according to its morphology. It takes into account its parameters and allows it to be classified. Parameters consider topological, spatial, kinematics and rendering features. Then, stored 3D parts can be edited to create new components using a Blender edition plug-in or to build a complete animal. Different to other systems, categorisation can be done by the user according to the part's appearance and it is not necessarily linked to biological taxonomy. 3D objects can be indexed based on their shapes using shape based retrieval applications [17]. Searching a large database of 3D meshes the user finds parts of interest, cuts the desired parts out of the meshes, and composites them together in different ways to form new objects. However, these approaches [18, 19] do not allow the parameterisation or animation of components and do not consider organic beings.

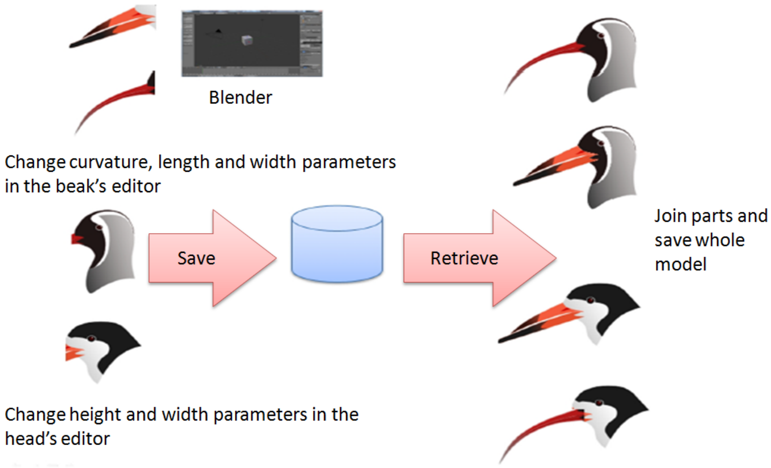

Fig. 3. Model by parts and persistence using parameters and edition tools.

In our model we required a generic and flexible classification platform which would allow a user define his/her own subdivision and parameters. For example (Figure 3), using one plug-in, we alter a bird's peak in terms of its curvature, length and width. Using another plug-in, we alter a bird's head in terms of its height and width. The new sub components can be stored in a graphic databank (or retrieved from the databank to create a new one). Once we have the components, we retrieve a set of them to create a complete animal model that is stored in the databank. The graphic databank stores any animal model and sub-model with its parameters. We achieved this implementing a database model. Here, a real animal is associated with a virtual animal. Next, the user can choose, edit or create a virtual part. Then, he/she can alter or define new parameters. Once the animal is complete, the user can decide to store it as a complete virtual animal. The model supports the definition of any parameter and its insertion with a SQL command. It also allows referencing a part's structures such as a 3D mesh to be stored as an attribute. Taking advantage of the latter feature, the user has the option to store complex information such as part's animation skeleton and kinematics.

Our first plug-in allows creating animal's legs/arms shapes with their animation skeleton. The editor relies on a mathematical model that uses metaballs organised along Bezier curves and a GUI allows the easy introduction of parameter values. Metaballs are obtained from the summation of spheres which parameterises the fusion of the spheres. The idea is to define a field of attraction for each metaball which is related to its radius of influence. The attraction between several aligned spheres creates a tube like shape suitable for limbs (Figure 4A). Other shapes such as a hand's palm (Figures 4B and D), can be obtained by arranging the interacting metaballs differently (e.g. along an ellipse). The tubular path of metaballs can be defined using Bezier curves. Once the basic leg/arm shape has been created it can be modified using the GUI (Figure 4C). The user can alter parameters such as curvature, orientation of parts with respect to each other and finally assign an animation skeleton, store the model in the editor and submit an insertion query to the data bank. The animation skeleton is created automatically once the limbs shape is finished. Then, the algorithm blends all the metaballs and creates a polygonal mesh. At this stage, bones are placed in each sub component of the limb (Figure 5D). We re-created the shape of Dry Forest' animals' legs (Figures 5A, B and C).

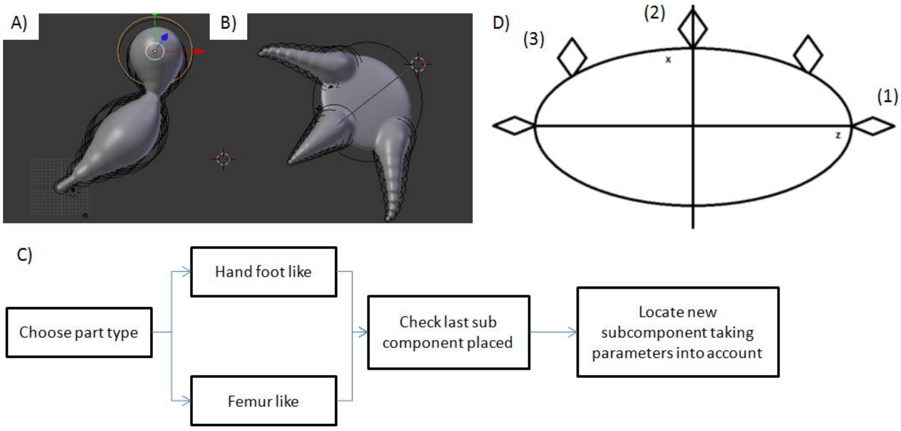

Fig. 4. Arm / leg editor. A) Tubular shape with metaballs using different radii along the path. B) Foot using Bezier curves for the fingers and an ellipse for the palm. C) Workflow for building a leg / arm. D) Primate foot finger distribution.

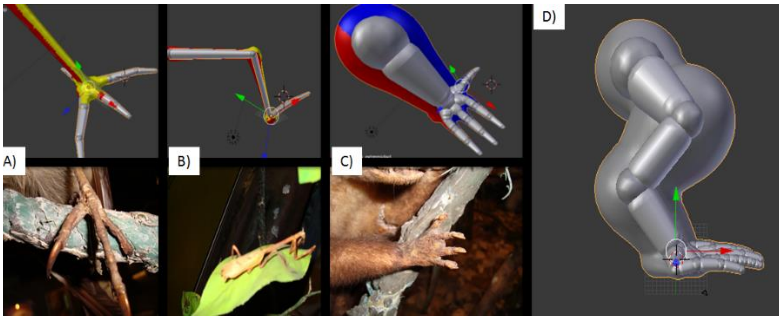

Fig. 5. Blender plug-in generated leg / arm. A) Birds. B) Insects. C) Mammals. D) A primate limb with its skeleton.

5. CONTENT MANAGEMENT

The content management model is fundamental to provide a flexible tool for the creation of content and narrative to entertain and educate on museums. In our model we rather followed the human collaboration approach [20] allowing the users to create and complement their classifications. Figure 6 shows the entities which support the model. Here, the most important element at a museum is the object (meaning an object at an exhibition). All museum's objects belong to one museum's collection. Both, objects and collections have historical events while they are at the museum (history). Also, they can have one or several locations. For example, the location where the object was found or the location where the object is kept. A person can be in charge of a collection or could have found an object (people). Finally, collections and objects can have associated characteristics such as size, colour or texture (among others) or documents such as photographs, 3D mesh, multimedia, papers.

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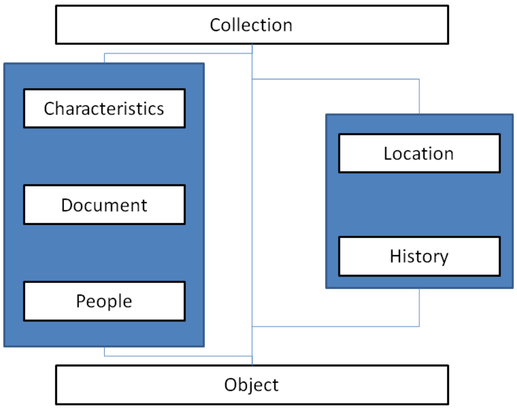

Fig. 6. Entities in the model.

6. CONCLUSION AND FURTHER WORK

We have described our advances towards a model for edutainment content generation at museums, providing some hints on how the system should be flexible and not intrusive. However, some parts of this architecture are still conceptual and require further development (particularly some aspects of the high level integration of the tools). Our main advances include: an AR book, a preliminary virtual reality environment, a 3D modelling tool, and a content management system. Furniture, signalling, posters, systems based in technologies and objects from the exhibition do not need to be discarded even when they are specific to one thematic and cannot be changed. MOMU's final goal (the heart in Figure 1) is to create a tool capable of integrating whatever is desired to create a particular educative and entertaining experience. For example, we have been able create entertaining experiences inspired on museums histories, exhibitions or scenarios [21] that could be integrated with MOMU.

With our AR book, we have been able to: (1) include all major data types such as 2D static; 2D dynamic; 3D content and sound; (2) offer an authoring interface based in a dialog box based interface; (3) the authoring tools allow to create pages and to introduce markers with related elements such as: virtual models, animations, videos, sounds, images and Kinect based gestures in order to create any book. We still need to enhance the book by providing marker-less AR, and by providing pages where the visitor cannot just read and look but create new content.

We take as a precondition that a set of animal components can be classified and stored and then put together to create a new animal. We aim to facilitate and ease part creation to non-experts through a set of parameters supported by a mathematical model and a graphics classification which follows a morphology defined by the user. These features bring opportunities such as the definition of different morphological taxonomies consistent with the user's anatomical knowledge. The graphic data bank is flexible and allows the inclusion of any part with its parameters, but the parameters defined in the Blender plug-in are not dynamic. We would expect to have at least the following additional basic Blender plug-ins: body, head, eyes, ears, mouth, beak, wings and tails, in order to rapidly create whole animals.

We have created a database capable of storing all the information and documents related to objects and collections. However, we still have not achieved complete flexibility and integration in the model. While we believe that programming and model evolution will always exist, we expect that in the future all of the model components will ease the work of the multidisciplinary team building an edutainment experience.

FOR DEEPER KNOWLEDGE

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