



# Conceptual Framework for Supporting the Creation of Virtual Museums with Focus on Natural User Interfaces

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**Abstract.** The Virtual Museum is an important instrument that allows people access to works that are often inaccessible due to the physical location of traditional museums. However, oftentimes developed Virtual Museums present problems that directly affect its usability. Thus, in this article the conceptual framework VWNUI (Virtual Museum with Natural User Interfaces) is proposed, which provides a conceptual model and guidelines related to the Natural User Interfaces to support the developers of Virtual Museums. The conceptual model is composed of elements and sub-elements that a Virtual Museum must contain, while the guidelines propose recommendations that the Virtual Museum should follow. To verify its applicability, the framework is supporting the development of a Virtual Museum to safeguard the history of a city. The Museum is still in the development phase, however, from the experiences reported by some users, it can be observed that the proposed framework can help and stimulate the creation of Virtual Museums that promote better experiences to their visitors.

**Keywords:** Virtual Museum · Conceptual framework · Natural User Interfaces Usability · Communicability · Interactivity

## 1 Introduction

The Virtual Museum is an important means of communication that allows preserving historical information that is often lost. It constitutes an environment that breaks the barrier of space and time and can, according to [14], facilitate the informative, pedagogical and aesthetic reception provided by conventional museums. The virtual museum takes little time to be built (compared to physical museums), is independent of geographical location, and is an alternative for many individuals who do not know of the existence

of physical museums or are not motivated to visit it, because of different reasons that can difficult access.

[11] analyzed 36 Virtual Museums and found several usability gaps that directly affect the public accessing these museums, discouraging them from exploring the content they offer. In this context, the Natural User Interfaces can be a solution to usability problems, since, according to [1], the user can interact with digital content using gestures, sounds, and ringtones, which are more intuitive than the use of artificial control devices. According to [18], many users do not have much intimacy with computer systems, allowing the Natural User Interfaces to assist these user profiles.

Thus, it is possible for users to take advantage of the skills acquired during their daily practices, and this, in turn, contributes to the learning time for using the Natural User Interfaces to be less than that required for learning a traditional interface.

Considering this scenario, it is important to propose models that support designers of virtual environments in the creation of spaces that provide good interactivity, intuitiveness and usability. According to [12], the framework is described as a model that can be reused several times to create new software. Connecting this concept with the Natural User Interfaces techniques is possible to have guidelines for creating Virtual Museums that provide good experiences to users.

Thus, in the work is proposed a conceptual framework to support the creation of Virtual Museums with focus on Natural User Interfaces. The methodological steps involved 4 stages: (i) Diagnosis of the elements that should compose a virtual museum; (ii) Diagnosis of the characteristics of Natural User Interfaces; (iii) Proposing a conceptual framework to support the creation of Virtual Museums; (iv) Validation of the framework in the creation of a Virtual Museum to safeguard part of the patrimony of a city.

## 2 Natural User Interfaces

[21], show that natural expression is directly linked to the way users use and how they feel during the use of those applications. Therefore, the Natural User Interfaces (NUI) are defined as a completely invisible interface, which, even so, allows the user to use it in a practical and increasingly better way.

According to [3], NUI's arises with the goal of using daily user skills for interaction with content. In this way, it is possible for users to take advantage of the skills acquired in their daily lives and this, in turn, contributes to the learning time for using the Natural User Interfaces is less than that required for learning a traditional interface.

[9] defines the seven main characteristics of the Natural User Interfaces, which are listed in Table 1.

**Table 1.** Characteristics of Natural User Interfaces.

Characteristics	Definition
User-centered	Attend the needs of different user profiles
Multi-channel interface	Use sensory and motor channels to gain additional attributes of users' intentions and thereby increase the naturalness of the interaction
Inexact	Understand the demands of users and correct possible mistakes made by them due to the inaccuracy of the users' thinking
High bandwidth	Consume high bandwidth to process the large amount of input information, such as voice and image
Voice-based interaction	Study how users use the system by voice, whether natural or synthesized
Image-based interaction	Use human behavior, to understand the picture and then make some decision
Behavior-based interaction	Use user behavior through the position, movement, and characteristics of expression of parts of the human body to understand action and make decision

Various types of devices can aid in capturing motion and sound and contribute directly to the Natural User Interfaces, such as 3D sensors, microphones, cameras and touch sensitive devices. Thus, any type of movement or human activity can serve as input for systems that interact with Natural User Interfaces, such as gestures, manipulation of physical and virtual objects, body movements, facial expressions, voice input and sign language [6].

It is possible to understand that the presentation of the interface and interaction is directly linked to the mode of reaction of the user when using the technology, be it positive or negative. Interaction interfaces, according to [10], influence positively when using different sources, well combined colors, graphic elements and the disposition of all these attributes to create a good interface.

According to [20] these types of interfaces help to reassure the user, and, more patients, they can wait for a longer time to load the site, for example. However, according to [15], when the interface is confusing or does not work right, users may feel offended, and most often become annoyed with the application. These difficulties encompass the entire computational scope, including the Virtual Museums, technological environment which is discussed in this work.

### 3 Virtual Museums

According to [17], a virtual environment can be defined as a graphical environment that simulates the presence of the user in this environment, through a computer and the elements that compose this virtualization.

According to [13], a virtual museum can be defined as a collection of digital content that is made available on the web. One of the advantages of this type of technology, for [5], is the possibility of check works that are present in physical locations that are often inaccessible to their users. Already for [4], the main advantage is the enrichment of the

virtual environment through virtual multimedia such as texts, graphics, animations, videos, among others.

It is also emphasized that in a virtual museum, it is possible for each visitor to create their own route of interest, according to their experience, personal tastes and cultural level. In this scenario, it is important that the environment is accessible enough to include inexperienced or somewhat disabled users who limit them to using environments that are not accessible.

The Virtual Museums are classified into three groups by [7]:

- Group 1: collections existing only in the virtual environment, without referents in the physical world;
- Group 2: collections with referring in the physical world, the virtual museum being a digital presentation of what already exists; and
- Group 3: there is no physical reference, but the collection exists physically and has been digitized and made available in a virtual environment.

Another classification concerns the types of Virtual Museums, which can be: two-dimensional, three-dimensional and digitally modeled. The two-dimensional presents only texts and photographs, in which the user can select some information that needs to be seen and to obtain more details through the presentation of a figure coming from the collection. The three-dimensional present a real environment (through a photo or film) providing the user a rich interaction, given that he can navigate as if he were walking in a physical museum. The digital models are widely developed with digital forms, not having photos or movies that exist in the real world.

Independent of the group to which it belongs or of its type, [11], developed a study on the usability in Virtual Museums in which they highlighted the main problems:

- Virtual museums have large amounts of content: too much content can irritate users, who will spend less time in the website. In addition, users can make selections without considering all options. Therefore, many explanations about the same content may confuse users who want information about a specific topic.
- Virtual museums use artistically designed graphical user interfaces: this type of layout can cause disorientation and distraction for users who wish to take some action. In addition, the elements of this type of interface can be confusing and meaningless to users.
- Virtual museums have interfaces that encourage exploration: this type of interface encourages navigation, as well as requiring users to make choices without understanding its consequences.
- Virtual museums are designed by museum professionals: when Virtual Museums are developed by people who work with museums, specific vocabularies and organizational schemes are used that are unfamiliar to people who are not in this context.
- Virtual Museums are often intended to complement physical museums: in this case, users have access to information they want both before and after the physical visit. The virtual visit is a complement to the physical visit.

Considering all these factors, and based on the characteristics of the Natural User Interfaces, a conceptual framework is proposed that intends to support the construction

of three-dimensional museums that provide good usability and a friendly, intuitive and interactive interface.

## **4 VMNUI: Conceptual Framework for Supporting the Creation of Virtual Museums with Focus on Natural User Interfaces**

Commonly, in software development, it is realized that developers use the same resources to develop new programs. In this sense, framework is understood as a model that can be reused several times for the creation of new software [12]. [19] shows that in addition to being a standard model, a framework has characteristics that are adaptable to the needs of the developers, so that their classes are customized when there is a need.

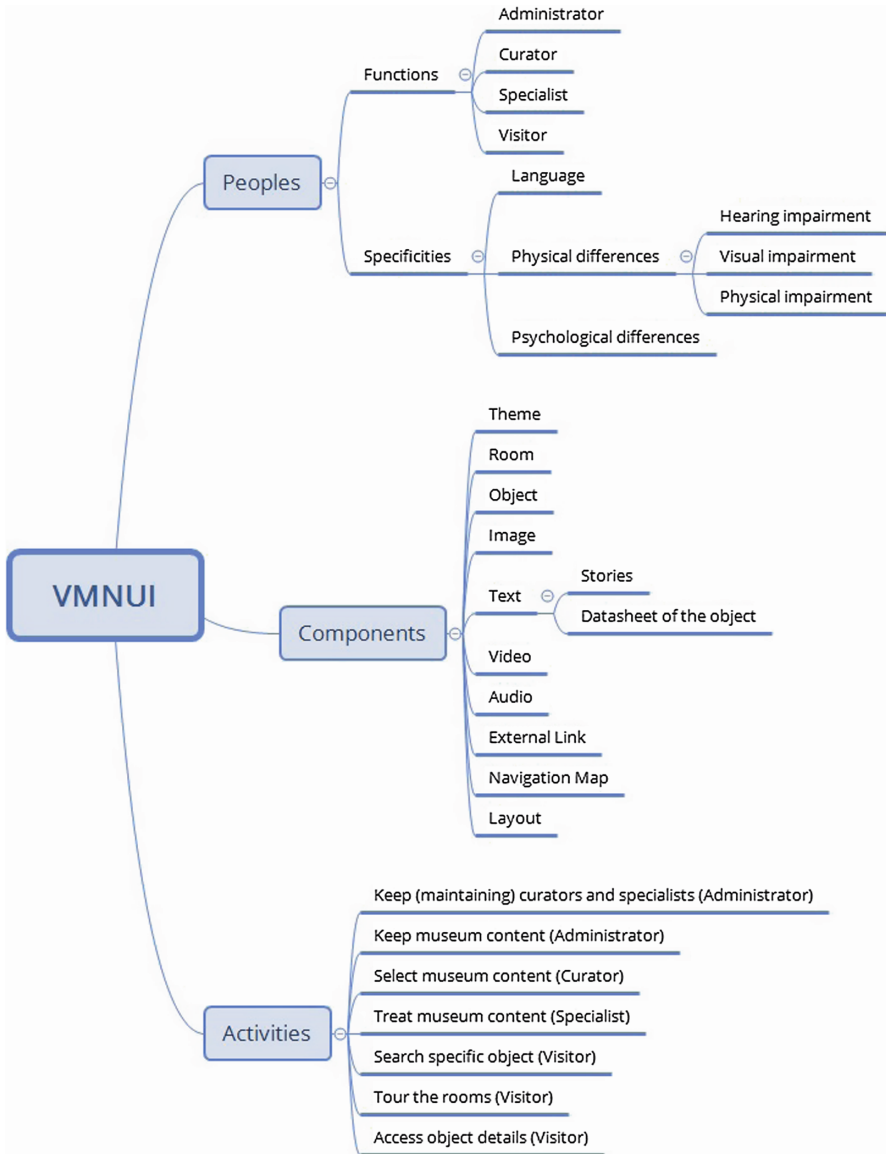
A conceptual framework, which is the proposal of this work, is an abstract representation that forms real world patterns, so to relate this abstraction to the software in development [16]. For [8], a conceptual framework means that the product generated from the use of the framework is not executable software, its main objective being to propose a conceptual schema of the data that will be used later to make explicit the specific data of the application. This conceptual scheme represents an interconnected system, or a relation of suppositions, expectations and/or beliefs, resulting in a provisional theory guiding research.

Based on the diagnoses made and based on the main factors of the interactive systems design proposed by [2], and also, mainly, by the work of [17], is proposed the conceptual framework VMNUI (Virtual Museums with Natural User Interfaces). The framework is composed by the conceptual model and the proposed guidelines, with emphasis on the Natural User Interfaces, seeking to support the creation of three-dimensional Virtual Museums.

The conceptual model proposed here is a work of the group of IHC, which develops two complementary researches, this with a focus on Natural User Interfaces and the principles of usability, interactivity and communicability, and the other focusing on the accessibility aspects of Virtual Museums.

### **4.1 Conceptual Model**

The conceptual model, which considers the inherent aspects of a virtual museum, presents three elements, following the organization proposed by [2]: (i) People, who have their roles in the use of the virtual museum, and their specificities, as specific languages and physical or psychological differences; (ii) Components, that are the ways in which the contents will be arranged in the virtual museum and (iii) Activities, which are linked to the functions that each role plays. The conceptual model is shown in Fig. 1.



**Fig. 1.** Conceptual model of VMNUI (Virtual Museum with Natural User Interface)

**Peoples**

It can be said that it is impossible the existencia of a virtual museum without the collaboration of people who contribute to the growth of this museum. Thus, in the model are presented the different roles that people can assume in the Virtual Museum.

- Administrator: responsible for maintaining (registering, altering, excluding) curators, specialists and museum content.
- Curator: responsible for selecting the content that will be made available in the museum.
- Specialist: responsible for the graphic treatment of the content that will be made available.
- Visitor: anyone who accesses the museum.

### **Components**

The components are part of the content that can be displayed in the museum. The more diverse and attractive the exposure of the content, the more interactive and accessible the museum will be. The components that can contain a Virtual Museum:

- Theme: refers to the main theme of the Museum, and can be related to any type of art or exhibition.
- Room: environment that contains several elements related to a specific subject linked to main theme.
- Object: a three-dimensional object, related to the theme and that may be available to the user touch for manipulation and observation.
- Image: can be a captured image (photo) or digitally generated image.
- Text: information available to the user about some art or exhibition. It can be in the form of Historical Reports or Object Data - technical information about the object, such as its date of manufacture, owner, among others.
- Video: element that presents the audiovisual narrative of facts
- Audio: element related to the recording, playback and transmission of sound.
- External link: hypermedia element with featured part that allows triggering another document that can contain a news of the object or exhibition, location of the physical museum, among others.
- Navigation map: "plant" of the virtual museum, which allows the visitor to locate within the navigation.
- Layout: content organization for user access, and view of the elements.

### **Activities**

People can perform different functions in Virtual Museums. For each function the main related activities are described:

- Administrator
  - Maintain curators and specialists: responsible for including, altering or excluding curators and museum specialists.
  - Keep content of the museum: responsible for, keep the content sent by the curator.
- Curator
  - Select the contents of the museum: person with extensive knowledge about the theme of the museum. It selects the content, arts and important exhibits that the virtual museum will have.
- Specialist
  - Treat the contents of the museum: responsible for dealing with the contents of the museum, providing images, videos and audios with good resolution.

- Visitor
  - Search and access a specific object: directly search for an object of your personal interest, without browsing other rooms and accessing objects that are not in your interest.
  - Take a tour of the rooms: make a visit as if you were in a physical museum, accessing different objects and browsing the rooms.
  - Access object details: access information from different objects, such as date of manufacture, owner, place that has been rescued, etc.

We can observe that the conceptual model provides a base of elements and sub-elements for developers of Virtual Museums. It is not necessary that the virtual environment has all the elements and sub-elements proposed in the model, but the more diverse the display of the content, the more interactive and enjoyable the Museum will be.

## 4.2 Guidelines for Creating Virtual Museums

As previously mentioned, the conceptual framework is also composed by some guidelines that have the function of assisting virtual museum developers in constructing more intuitive and pleasant environments.

Considering that because it is independent of geographical location, Virtual Museums can reach a wider range, it is necessary stay tuned for some important aspects related to the diversity of **People** that can access the Virtual Museum, they are:

- **Languages:** The virtual museum must have a multilingual translation option, covering the widest possible audience, regardless of the language spoken by the visitor.
- **Physical differences:** attention must be paid to the different types of deficiencies (auditory, visual, physical, psychological, among others) and the limitations they can impose on access to a virtual environment. Some important project decisions can minimize these limitations, such as interaction through the use of voice commands, in the case of the visually impaired, and the use of more intuitive and good signaling paths in the case of cognitive limitations. As previously mentioned, a complementary study to this research thoroughly discusses issues related to accessibility in Virtual Museums.

In the **Components** axis, the elements that are contained in a Virtual Museum are described, therefore, for this axis are listed the main guidelines proposed in this research, linked to the use of the Natural User Interfaces.

- **Use 360° images for better navigation in the virtual room, where the user can rotate in all possible angles and walk through the museum, as if visiting a physical museum:** linked to the ROOM sub-element, this guideline concerns the user's browsing mode during their virtual visit. The development of Virtual Museums can have different paths that depend on the choice of museum dimension. Virtual museums can be two-dimensional, three-dimensional or digitally modeled. For this



guideline to be covered in development, it is necessary for the museum to be three-dimensional. Thus, through the 360° room, made by means of equirectangular photos it is possible for the user to rotate horizontally 360° and vertically 180°, having the impression of actually being inside the room.

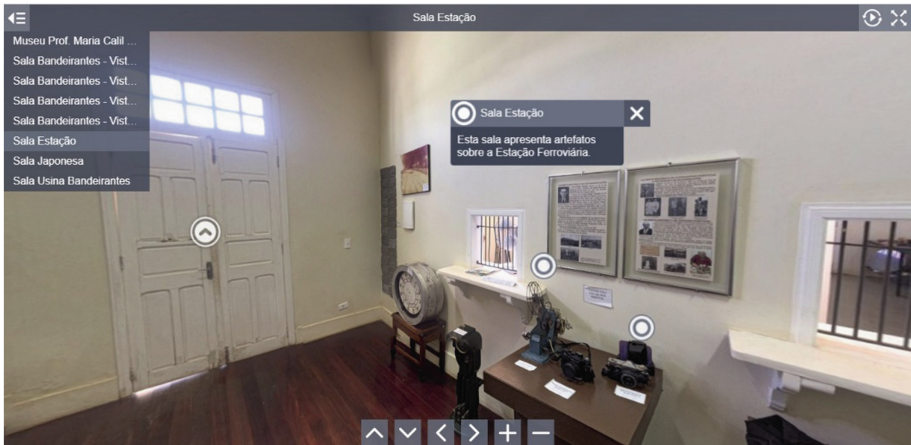
- **Use 3D function so that the works can be rotated horizontally, exploring every detail of the exhibition:** this guideline aims to increase the interaction of the user with the museum, so that the information sought by the user is passed in the most natural way possible. Therefore, it is necessary to make the works available in 3D format, so that users can rotate them and from various angles observe all the details of the object. Linked to the OBJECT sub-element, this guideline provides an interaction with optimal usability to the user.
- **Use the touchscreen interaction of the user, providing better usability and interaction of the same with the software:** the touchscreen interaction is an example of a Natural User Interface, which according to [3] aims to use daily user skills to facilitate interaction. In this case, the touchscreen will be used in the manipulation of the 360° room and 3D objects. Linked to the LAYOUT sub-element, this guideline provides the possibility that just with the touch the user can navigate through the Virtual Museum and have experiences as if in a real environment.
- **Allow the voice command to perform some action, so that the museum becomes more accessible:** linked to the SPECIFICITIES sub-element, this guideline fits into issues of disability and accessibility. Voice recognition is also a mechanism that is embedded in the Natural User Interfaces. Therefore, it is necessary that the Virtual Museum has forms of voice capture for the execution of an action. If user has a physical disability that prevents you from navigating in a simple way through the touchscreen, voice recognition will do the job and the user can navigate in the same way.
- **Give attention to the questions of physiology and kinesthesia, avoiding difficult movements and very repetitive actions:** according to [11], Virtual Museums must contain interfaces that stimulate user exploration. However, care must be taken with the difficulty and repetition of actions. Linked to the LAYOUT sub-element, this guideline refers to the user-friendly interface, which needs to be exploratory, making users feel at ease both to search for specific content and to navigate without direction. In addition, users need to clearly understand the consequences of their choices and locate quickly if they are looking for a specific item.
- **Give attention to quantity of information and your exhibition, seeking to promote good visibility of all elements of the interface:** yet according to [11], Virtual Museums must possess a correct amount of information and content. Linked to the LAYOUT sub-element, this guideline seeks to guide the care of not inserting in the virtual environment excessive information that suffocates the user. Too much content can irritate users, who will feel unmotivated and leave the Virtual Museum. In addition, the excess content can make the user not know what is accessing and focus only on one area, without knowing the existence of others. Also, for those looking for specific content, a lot of information about this content can confuse users who perform a simple search.

These guidelines are intended to support the development of Virtual Museums with good usability and interactivity in order to please their end user regardless of the theme of the content displayed in the museum. These guidelines were applied in the development of a Virtual Museum that sought to contribute to the historical rescue of a small city in the interior of Paraná - Brazil.

### 4.3 Application of the Framework in the Creation of a Virtual Museum

In order to verify the applicability of the framework proposed in this work, it began the process of developing a Virtual Museum to safeguard the history of the city of Bandeirantes - Paraná/Brazil. The Museum is under development, following the proposed elements and guidelines.

In this way, as it is possible to be observed in the Fig. 2, were created 360° rooms related to the relevant collections of the museum, in which the user can rotate for all the angles. This guideline presented by the framework increases the user's ability to interact, giving him the impression of visiting a real environment.

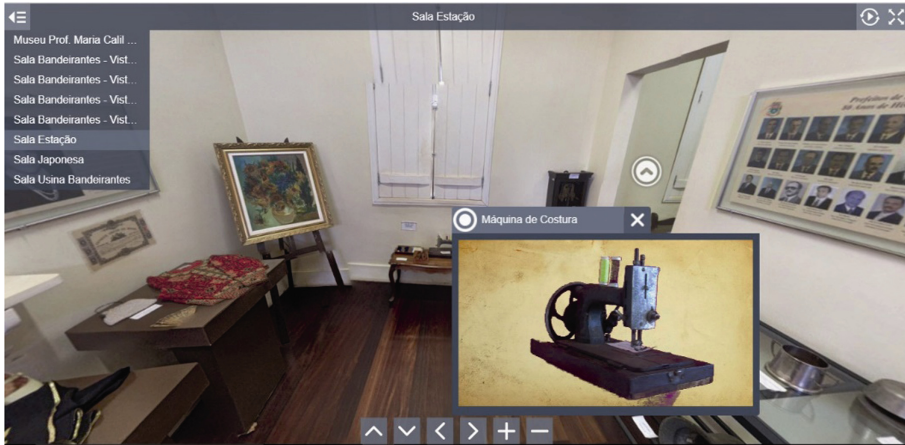


**Fig. 2.** Example of a 360° room developed in the Virtual Museum.

In Fig. 3, one can observe the use of a 3D object. When the user clicks on an object, the object is displayed in 3D format. Then, the user can rotate it horizontally, observing all the details of the work.

Also, the Virtual Museum under development follows the guideline related to kinaesthesia and physiology, providing easier and intuitive navigation to the user. The amount of content and elements made available in the museum was also selected in order to follow the last guideline provided, and with this, the Museum presents a cleaner interface to provide better visibility to the user, who has easy access to all available information.

As the Museum is under development, not all elements and sub-elements have yet been created, nor have all the proposed guidelines in the conceptual model been applied. Sub-elements such as video, audio, and external link are being prepared to be inserted



**Fig. 3.** Example of using a 3D object available in the Virtual Museum

into the environment. The guidelines that refer to the use of voice recognition and aspects of accessibility are being addressed, as already mentioned, in a parallel work by this research group, considering the complexity and breadth of its implications.

Thus, based on the findings of [11], and considering the use of the guidelines proposed by the framework VMNUI already made so far, it is possible to observe that the Virtual Museum presents: a quantity of non-excessive content; a real environment (which was not created artistically) seeking to bring more meaning to the user and a clean interface in order to facilitate and encourage its exploitation.

A first version of the museum was made available to a group of users (8 people) who used the virtual environment and provided feedback on their experience. From the reports, it was observed that, following the elements and guidelines proposed by the VMNUI, it was possible to create a virtual museum that would provide, in general, a good navigation experience. Some issues were pointed out, among them, the difficulty of people with disabilities in the hands of executing commands that require greater intervention, such as the rotation of an object for example. Thus, although the Natural User Interfaces contribute positively to the accessibility of the environment, it is very important to add the accessibility guidelines (already under development in parallel work) to the VMNUI framework.

## 5 Final Considerations

The museum, being an important means of communication, needs to take advantage of all the technological and communication development available, in order to improve the process of interaction with its public. There are several Virtual Museums available on the web, however, the vast majority have a limitation in relation to navigation, not taking advantage in a significant way of the functions that virtuality offers.

In this sense, the Natural User Interfaces can be presented as a good alternative to make navigation in a virtual museum more attractive and intuitive, in which the senses are better stimulated and provide a greater sense of being in a real environment.

Thus, this research presented a conceptual framework - VMNUI to support the creation of Virtual Museums as a focus on the use of Natural User Interfaces.

For the development of the conceptual model were listed and analyzed the main elements that should compose a virtual museum. Based on the composition of the elements, guidelines based on the use of Natural User Interfaces were proposed.

The application of VMNUI was started in the development of a Virtual Museum that rescues and makes available the historical data of a municipality. The museum has contents of the rural area of the city, as well as pieces about inactive railroad that passes through the city and objects of Japanese culture. The whole museum was arranged in three rooms 360°, in which it is possible to rotate the 3D objects that the room has. The elements were arranged so as not to overlap and in a way that facilitated the handling action.

A group of people, had access to the first version of the Museum, and could relate their experience in the environment. From the experiences reported it can be observed that the proposed framework can support and stimulate the creation of new Virtual Museums, which enhance interactivity, communicability and intuitiveness.

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