Development of a Museum Exhibition System Combining Interactional and Transmissional Learning

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Abstract

We develop an interactive exhibition system for museums, which combines learning based on the interaction with objects and learning based on knowledge transmission. The system uses RFID technology to determine the grasping state and feed back the content. We present the actual implementation of the system inside a museum.

Keywords: Museum exhibition, Interactional learning, Transmissional learning, science education, RF-ID, Augmented Reality

1. Introduction

In contrast with the conventional exhibition format in which exhibited objects cannot be touched, Caulton (1998) presents an interactive exhibition system called "Hands on". "Hands on" is characterized by the interaction with objects, and according to Koran et al. (1986), exhibits with which it is possible to interact attract the visitors and draw their attention longer than exhibits without interaction.

However, through the use of the sole interaction, for many exhibits some parts might remain impossible to be seen, and the information might be difficult to read. To solve this problem, one can suggest the effectiveness of knowledge-transmission contents, but this type of contents has a tendency to present information one-sidedly and might face difficulties attracting the visitors' attention due to the lack of interaction. Exhibitions are also organized with Hands On parts and knowledge-transmission parts in parallel, but objects and contents are then separated, which might result in a decoupling of the knowledge architecture.

Koshinishi (1996) said that Exhibitions in museums should not rely on single senses such as vision or audition to appeal to the visitors, but should assist their intuitive understanding by appealing in a composite way to many sensations.

For that purpose, Miles (1986) reaches several necessary roles for an exhibition medium:

1. Attract the visitor
2. Maintain the visitor's attention
3. Revive the visitor's knowledge
4. Provide information to the visitor
5. Stimulate the visitor's reaction
6. Give feedback to the visitor

"Participatory devices" have been introduced as media achieving such requirements. A "participatory device" plays speech or video content when an action is performed by the visitor, such holding a button down or manipulating a pointing device.

For exhibits to which the visitor paid attention, this kind of system indeed appeals to his/her senses as it combines with the exhibited item at this particular place and time to provide additional information. However, exhibited items are usually set in glass cases, making it impossible for the visitor to touch them. Interaction between the visitor and the exhibited item thus becomes limited, and the acquisition of knowledge from the exhibit is inhibited.

Taking such problems into account, “hands on” exhibitions, where visitors can actually take the items in their hands and observe them, are attracting attention. “Hands on” displays are headed for a learning model where the learner “discovers by himself through trial-and-error“, and follows the constructivist idea which considers the learner as a being reconstructing his/her interpretation of the world and the information he/she holds through interaction with the surrounding world. Through the experience of

1. Touching the item,
2. Manipulating,
3. Trying one thing or another,
4. Sensing something through manipulation,
5. Searching until one fully understands what one has sensed,

hands on displays arouse the spontaneous searching activity of the visitors, thus providing an environment which stimulates learning and the interest for the exhibition (Nezu 2003).

Even though hands on displays are able to reduce the distance between the exhibited items and the visitor and stimulate an autonomous behavior, in such conventional methods the additional information is still provided unilaterally, for example by the exhibition guideboards, and the items and the additional information are still decoupled, making these approaches insufficient to assist the intuitive understanding of the visitors. It is necessary to provide the items and the additional information in a more integrated and mutually complementary manner, more tightly linked to the context of each visitor. Engaging an interaction involving the five senses by a mutual feedback between the visitor and the exhibits on their reciprocal states, such a goal becomes realizable.

In the present study, we develop an interactive display system called "Monogatari” (in English, “narrative exhibition"), which employs ubiquitous technology to combine interaction and knowledge-transmission by embedding the media contents from the transmissional side directly into the interaction with the exhibited item.

2. Previous work

Ayres et al. (1998) showed through a study of primary school students at the Discovery center in East Tennessee that exhibitions based on multimedia stimulated more the understanding of scientific concepts than the usual hands on displays. This effect is thought to result from the fact that multimedia contents deliver the information by appealing to several senses and making full use of text and video.

Kondo et al. (2006) also performed user behavior analysis in a science museum exhibition where they visually combined, through the Mixed Reality technology, the displayed skeletal preparations of dinosaurs with a 3D model reconstruction of their body.

3. Monogatari system

The Monogatari system presented in this study is an exhibition system for museums which combines knowledge-transmission based learning and interaction with objects by using RFID technology and Augmented Reality.

Monogatari principally consists of a software which manages the exhibited item, the installation and the presentation of

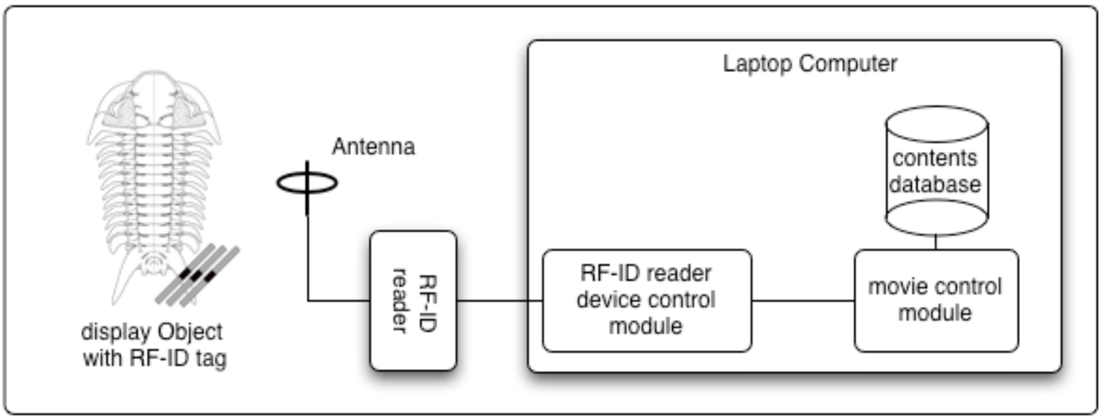

Fig. 1: System diagram

additional information.

1. The user wears a ring-shaped antenna device, takes the exhibited item in his/her hands and observes it.
2. By sensing the grasping state of the user, the system estimates on which part of the item the user's attention is focused.
3. Depending on the place where the user's attention is focused, a video content is played, superimposed onto the item.
4. When the user changes the way he/she is carrying the object and a variation of the grasping state is detected, the content is switched.
5. When all the contents have been seen, a concluding content is played to signify the user that he/she completed the viewing of all the contents.

By making the user observe the item through such a sequence, the additional information is provided as if the item itself was talking to the user.

3.1 RF-ID technology

In order to sense the grasping state of the exhibited item by the user, the system uses RF-ID technology. RF-ID is a technology which reads and discriminates the IDs of so-called "tags". These tags are composed of an antenna and a chip with a unique ID. Its used in supply chain management (SCM), logistics, etc., is spreading. Here, several tags are embedded in a fixed pattern in the exhibited item, and the grasping state of the user is sensed by reading the tag ID with the ring-shaped antenna worn on the finger.

As the RF– ID tags are to be pasted on the item or embedded into it, the size with the antenna included should be small. For the same reason, active-type tags with built-in batteries must be discarded, and one must use passive-type tags, for which the power is supplied by the reader and no built-in power source is thus required.

After performing experiments using several types of tags, we selected Hitachi's μ-Chip. The μ-Chip is an ultra-small (0.4mm square size) passive RF-ID chip performing communication in the 2.4GHz band, which can be used legally in Japan. The size of the inlet including the chip and the antenna is 51 x 1.5 x 0.25 (mm), and the tag can be used even when bent, making it suitable for a pasted or embedded use on exhibition items.

Table1: μ-Chip specifications

Size	0.4×0.4mm
Frequency	2.45GHz
Memory size	128bit
Writing	Disabled

We used as RF-ID reader device YAGI Antenna's MRJ200A, whose specifications are given in Table 2.

Table 2: MRJ200A specifications

Telecommunication standard	ARIB STD-T81
Frequency	2.407～2.426GHz
Stable reagin distance	60～100mm (with patch antenna)
Transmission power	10mW/MHz
Modulation system	A1D(ASK)
Interface	RS-232C
Power consumption	In use: ≦2.3W In standby: ≦0.3W

As written in Table 2, the transmission power is 10mW/MHz, and the device can thus be used legally in Japan without specific authorization.

We note that the MRJ200A cannot read several tags simultaneously, but this is not an issue for the application considered in this study.

We used the RS-232C as an interface to connect the device to a PC and control it.

In order to use the antenna as a ring, we built a small loop antenna. This small loop antenna does not detect the electric field but the magnetic field, and can be made extremely small compared to usual antennas.

The diameter of the antenna was set to 15mm such that primary school and junior high school students can wear it without discomfort. Moreover, the small loop antenna can by nature easily lose its gain through bending, and we secured its intensity by using steel wire.

As the adverse effect of the feeder cable coming from the RF-ID reader device acting as an antenna cannot be neglected, we used Balun with the small loop antenna.

The antenna was fixed with Velcro tape on

Fig. 2: Ring-shaped antenna

3.2 Projection equipment

The system uses a tablet type laptop PC set at the back of the display box to display information in the real world by projecting it on a half-mirror. This leads to an AR (Augmented Reality) system in which fossil replicas and video contents such as 3D animations, texts or photographs, are superimposed and can be seen simultaneously. By allowing the user to see video contents while touching the object (for example, when looking at the head of a trilobite, showing a video content about the trilobite's high-resolution eyes), one can display video contents related to the interaction with the object and thus stimulate the user's interest and knowledge building.

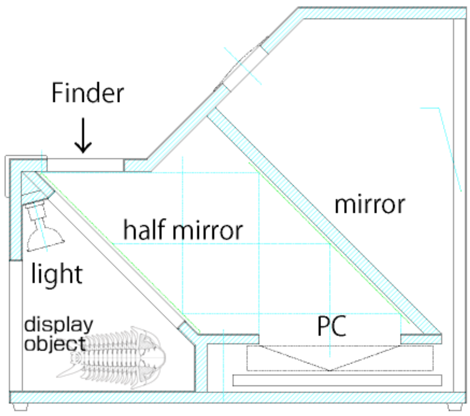

Fig. 3 Display box structure

Fig. 4 Display box picture

3.3 Software

The control of the reader and the video projection is performed by the laptop PC installed in the display box.

The software is composed of a RF-ID reader control module and a movie control module.

・ RF-ID reader device control module

This module performs the initialization of the RF-ID reader device, the reading control and the code analysis. At regular time intervals (usually every second), the ID is read by the RF-ID reader device; if an ID was read, after normalization and check for duplicate, if the ID is valid, it is handed to the movie control module. The module is a windows application created with C# and .NET Framework.

User session administration is also performed, such that if a content has already been displayed to a user, even if the same signal is received again this content is not re-displayed. If the user takes of the ring-shaped antenna and puts it on the display box, a specific RF-ID tag is sensed and the session is reset.

・Movie control module

This module receives a signal from the RF-ID reader device control module and, after comparing it with a database, displays the appropriate content. It is implemented using Flash 8.

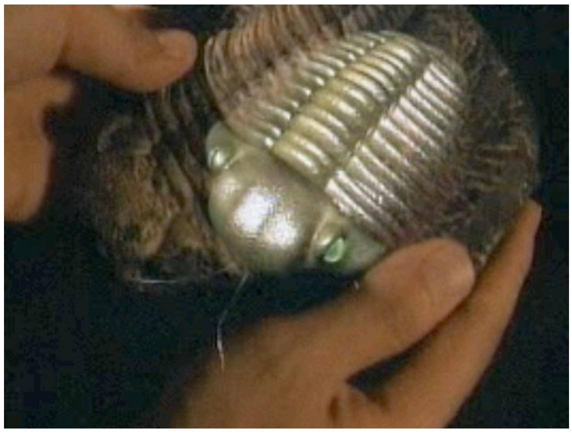

Fig. 6: Example of projected video

The standby display is shown until the RF-ID reader device control module receives a signal. The corresponding movie is then played, and when it is finished the system goes back to the standby display. When all the contents have been played, the user is informed of the end of the session.

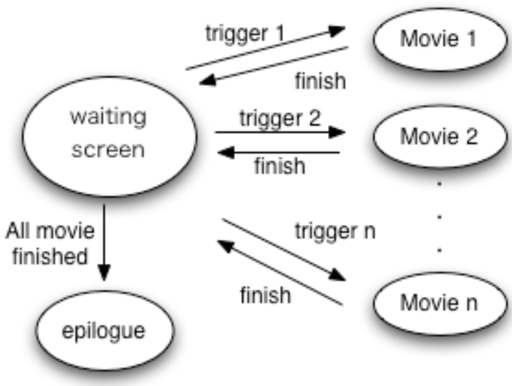

Fig. 5: Movie diagram

When a movie is being played, signals coming from the RF-ID reader device control module are ignored, and priority is given to the movie.

4. Contents

In this study, we selected the trilobite as a first subject. It is nowadays possible to take a trilobite fossil in one's hands and observe it, but this interaction is not enough to learn about the original aspect of the fossil. Our system assists the knowledge building about the trilobite by linking the fossil with its original aspect.

A trilobite fossil replica was built for exhibition. RF-ID tags were embedded about 2～3mm inside the surface of the replica. To avoid interference between tags, they were disposed at intervals of 10mm. A total number of 20 tags were embedded on the front and back of the replica.

The video contents currently feature the following movies, but additional contents can be added as needed:

・the standby display

This video invites the visitor to use Monogatari and encourages him/her to try different ways of holding the item

・The trilobite and its congeners

This video presents the different types of trilobite and explains how it evolved.

・Background of the trilobite's flourishing age

This video explains how the earth and the other living organisms were during the Cambrian and Permian, when the trilobite lived.

・Life form

This video explains the characteristics of the trilobite's body and the characteristic means of defense it is thought to have been using against the attacks of its enemies.

・Presentation of the compound eye

This video presents the principle, characteristics and advantage (the high sensibility to movement within eyesight) of the trilobite's compound eye.

To emphasize the feeling of interaction between two beings, the exhibited item and the user, we designed the narration as if the trilobite was talking to the user.

Apart from the standby display, we kept the contents' length within 60s to 90s such that the user does not get tired.

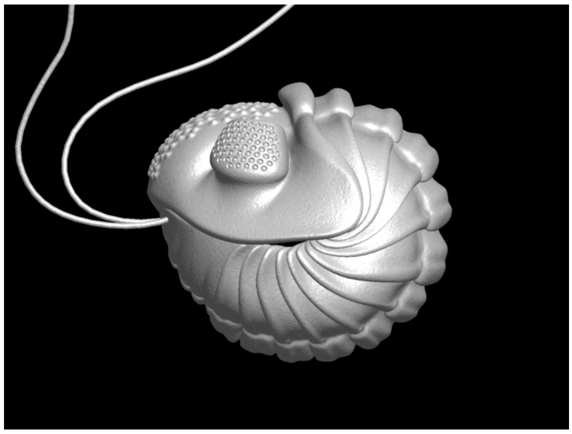

Fig. 7: Movie of the trilobite's defensive

5. Preliminary experiment

5.1 At Museum

A preliminary test was performed in August 2007 at the Kanagawa Prefectural Museum of Natural History.

The Monogatari system was installed in a corner of the exhibition space. A survey based on a questionnaire and an interview was conducted on primary school and junior high-school students (6 to 13 year old) who visited the exhibition, after they actually used the system.

Through this experiment, the following problems emerged:

・Insufficient sensitivity of the RF-ID

With the antenna on and while holding the item, sometimes the RF-ID tag could not be read and the grasping state could not be sensed, or the response was bad. The grasping state could then be sensed after slightly changing the grip, but it appeared that it was necessary to rise the sensitivity of the RF-ID to display movies to the user in a more natural way.

So, we has re-designed an antenna and cable between antenna and RF-ID reader device to rise antenna gain and hold down capacity of cable. On the other side, we kicked around about pattern of embed RF-ID tag not to interference with other tag.

・Simultaneous viewing

As the exhibition is performed using a display box into which the user has to look, the experience can only be done with one user for one machine at a time.

However, in the target age-group we considered this time, visitors have difficulties waiting for their turn and try to have a look at what the preceding user is doing. We should thus consider a mechanism which enables other persons than the user to attend too, such as external displays for example.

・Usability

The software used this time could be easily manipulated by the junior-high school students, but primary school students sometimes encountered difficulties and in some situations were puzzled by its manipulation. Modifications of the system and the contents, such as the addition of navigation to the software, and the use of plain words in the explanations, are necessary.

We added guidance and navigation animation to the video contents to fix the problem.

5.1 Measurement of educational effect

Other preliminary experiment is performed in March 2008 at the University of Tokyo. The aim of this test is to confirm improvement of system after first experiment and measure educational effect of the system.

2systems (for experimental group and control group) are installed at lecture room.

System for experimental group is full featured Monogatari system and for control group is consist of object (trilobite fossil) and laptop PC. On the control group, examinee looks trilobite fossil (can't touch) and watch same contents on the laptop PC. video start with active key press of examinee.

On the both group, examinee took an paper test about trilobite and history before and after system operation to check their knowledge and what they get from system.

20elementary school students (10 for experimental group and 10 for control group).

We are analyzing the result of second experiment now.

6. Future research

We are currently improving the system according to the results of the preliminary experiment, and plan to perform a temporary exhibition in a natural history museum and experimentally evaluate the effect on learning and interest among children and pupils.

Expecting this project to grow as a full system, we also plan to enrich the movie contents and to expand the concept to other topics than the trilobite.

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