Innovative and Intuitive Hands-on Interaction with RFID to Enhance Digital Media Experience of Exhibits

Sandra Schadenbauer, Alexander Nischelwitzer, Robert Strohmaier, Gerhard Sprung
Information Management
FH JOANNEUM
Graz, Austria
sandra.schadenbauer@fh-joanneum.at, alexander.nischelwitzer@fh-joanneum.at, robert.strohmaier@fh-joanneum.at, gerhard.sprung@fh-joanneum.at

***Abstract*—RFID (Radio Frequency Identification System) technology is very popular today and is used in everyday life. However, RFID hasn't won much recognition in museums yet, especially not in the field of hands-on experience. This paper shows that RFID can be used for innovative and intuitive hands-on interaction to enhance digital media experience of exhibits in museums and presents several projects in museums, which uses RFID for the exhibits' interaction.**

Keywords—RFID, digital media; tangible objects; invisible tagging; exhibit; exhibition; museums; showrooms; hands-on

I. INTRODUCTION

The research field Digital Media Technologies (DMT) of the Institute of Information Management at the University of Applied Sciences FH JOANNEUM Graz develops multimedia implementations for different fields of application. DMT is active in numerous projects with interactive multimedia installations and stations for museums and exhibitions.

The DMT team strives to choose the right technology for the right purpose. Over the years, we applied the RFID (Radio Frequency Identification System) technology at various multimedia projects.

At the moment, museums use RFID mainly for security (protecting from theft) [1][12], artefact tracking (inventory) [1][2][10][12], ticketing[1] and tracking visitors' flow [4][5] – which is also a topic of our own research [13]. RFID is also implemented for enhancing the visitors' experience by providing additional information in different languages about exhibits with a "personalized" museum guide [1][5][6][7][11][13], which in some cases also collects data during the visit, so that visitors can take a part of the exhibitions home for the post-visit experience [1][7][11][13]. This is used for example in the travelling exhibitions "Heart over Heals" or "Show Me the Money", which we developed in cooperation with the Graz Children's Museum FRida & freD[1].

Most of the approaches and projects, which aim to increase the visitors' experience by using RFID technology, provide additional content about an exhibit or the whole exhibition, but do not offer "hands-on" experience. Therefore, DMT uses RFID for interactive multimedia exhibits, where objects, equipped with RFID tags, are essential to use and understand the exhibit.

This paper is organized as follows: Section II introduces the RFID technology and compares it to other methods of identification in the context of hands-on exhibits. Section III describes the software interface between RFID readers and exhibition software. Finally, section IV gives an idea of innovative and intuitive hands-on interaction with RFID by explaining some of our projects.

II. RFID

A. General

RFID stands for Radio Frequency Identification System and basically consists of a reader and several transponders (also called tags) [9]. Every RFID tag has a worldwide UID (Unique ID).

RFID is contactless and uses radio frequency signals for communication [8]. Readers emit radio waves, which are received by the tags and in turn, they response with data, which is read by the reader [9].

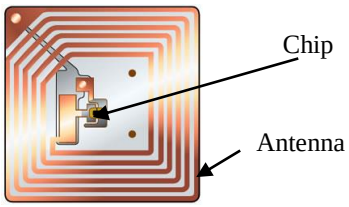

Fig. 1. RFID Tag[2]

[1] http://fridaundfred.at/

[2] Image Source: https://www.phidgets.com/SpecSensorSeries3/html/858x-/25/rfid-label-phidgets-usb-sensing-and-control.jpg

The RFID technology is very popular today and is used in everyday life, for example:

- Cashless/wireless payment [1][8]
- Ticketing [1]
- Access control [1][8]
- Smart home controls [1]
- Medical purposes [8]
- Warehouse inventory [8]
- Sport events [8]

RFID readers and tags are available in many forms and can be categorized by frequency (Low Frequency 9-135 KHz, High Frequency 13.56 MHz, Ultra High Frequency 0.3-1.2 GHz and Microwaves 2.45-5.8 GHz), size, tag technology (Mifare, ICODE, etc.), interface (USB, Ethernet, Serial, Bluetooth, etc.) and active (transponders with own power supply) or passive (transponders are powered by a reader's inductive field) systems. The reading range depends on these characteristics, and can cover a few millimeters to several meters [9].

Fig. 2. Variety of RFID Tags

The selection of the system depends on the requirements. In our projects, we have gained positive experience with passive ICODE tags from NXP[3], which operate on 13.56MHz (HF) supporting ISO 15693 and ISO 18000-3 [14]. The reasons are that ICODE tags come in several dimensions and forms and can also be processed by many readers with different sizes of antennas. We develop multimedia applications that mostly run on personal computers. The exhibition software communicates via an XML socket application with the reader, which is connected to the USB interface of the PC. Wireless communication would also be possible, but USB is more reliable.

Our RFID implementations can be classified by following characteristics:

- Mobility: stationary or moving readers
- Quantity: one or more readers
- Range: from 2 mm to 50 cm
- Usage: single user and multiuser applications

[3] https://www.nxp.com/

Fig. 3. Several RFID reader and antennas operating on 13.56 MHz

B. Differences to other technolgies like barcodes, QR codes and fiducials

Barcodes, QR (Quick Response) codes and fiducials are visual codes printed on paper or other material. They have one characteristic in common, they all need a line of sight to be identified. In many cases a conventional camera (webcam, smartphone cam, etc.) is used to identify these optical 1D or 2D codes.

A line of sight is not necessary with RFID tags. They can be directly built into different objects, for example in 3D printed bones. Therefore, various tangible objects with an invisible identification feature can be created.

Fig. 4. 3D printed bone with RFID tag inside

In contrast to RFID tags, barcodes, QR codes and fiducials are not unique; it is possible to print endless copies of them.

RFID tags can store more information than just the UID. Readers are not only able to read this data, but can also save new data on a RFID tag. However, readers only know that one or more RFID tags are near the antenna, but there is no information about the distance and so forth. Another challenge dealing with RFID is that metal and power supply lines can interfere the signal.

In contrary, fiducials additionally allow tracking the position and the rotation of an object. The downside of this technology is that the camera needs a stable light source to recognize the fiducials.

Our team uses all these technologies in different projects, but the overall experience shows, that the RFID technology offers one of the most reliable identification methods.

III. XML SOCKETS

We developed several XML socket applications to ensure the communication between the exhibition software and the API of different RFID readers. The XML sockets deliver

information about the reader and the identified tags with a certain XML declaration. This allows us to switch to a different brand of RFID reader with no need to adapt the exhibition software. Furthermore, it is possible to connect multiple readers to a personal computer at the same time. This allows us to identify the position of the tags (for example near reader A or reader B).

IV. PROJECTS

For more than 10 years, the DMT research group implemented the RFID technology in several projects. This section shows a selection of exhibits, which use RFID as a user interface.

A. Projects with stationary readers

In the following exhibits, we integrated one or more fixed readers and antennas, which cannot be displaced by the visitors. Users interact with the exhibit by moving the transponders. In these examples, we mostly use one or more ID ISC.MR102 readers and ID ISC.ANT310/310 antennas from Feig[4] which operate on 13.56 MHz (ISO15693).

1) Paint Walls: At this exhibit, walls can be virtually painted with a selected color. Multiple RFID readers are hidden in the paint buckets and walls, the brushes are equipped with RFID tags. For the paint buckets, we used smaller readers and antennas. The exhibit was developed in cooperation with the Graz Children's Museum FRida & freD for the travelling exhibition "Archinature".

Fig. 5. "Paint Walls" with RFID antennas behind the walls

2) Building A House: This exhibit is another development in cooperation with the Graz Children's Museum FRida & freD for the travelling exhibition "Archinature". Children get to know the process of building a house by placing the required tools and machines (which are equipped with RFID tags) on a property (with a RFID reader mounted beneath).

Fig. 6. "Building A House" with tangible objects

[4] http://www.feig.de/

3) The History of Writing: For the traveling exhibition "The Inventive Geniuses" we develop in cooperation with the Graz Children's Museum FRida & freD a book which tells about the history of writing. The book's pages are equipped with RFID tags and two RFID readers are placed beneath the bookshelf. With this information, the animated content of the book is projected on the blank pages.

Fig. 7. "The History of Writing" with RFID tags inside the animated book

4) Inventory: Children can recreate themselves with this exhibit, which was developed in cooperation with the Graz Children's Museum FRida & freD for the exhibition "My Family". RFID cards represent different body parts, clothes and colors.

Fig. 8. "Inventory" with RFID cards

5) Medical Doll: The goal of this project is to inform visitors about different medical child diseases and their treatments. A doll in the size of a child lies on an examining table with a large display. The doll is equipped with RFID antennas and responds to medical items (with build in RFID tags), like stethoscope, otoscope or magnifier. Feedback is given with a large LCD screen and also directly with a projection on the doll itself. This exhibit was developed in cooperation with the Graz Children's Museum FRida & freD.

Fig. 9. "Medical Doll" with build in RFID antennas

6) Effective Nature Conservation: This exhibit explains various tools of nature conservation. Wodden objects, which represent the tools, are equipped with RFID tags. RFID readers are mounted beneath the information- and the tool-pad. Visitors not only receive information about the tools, but they can also apply them in different scenarios. We developed this multimedia application in cooperation with the Styrian Nature Parks[5] for the exhibtion "Nature in Human Hands".

Fig. 10. "Effective Nature Conservation" with two RFID readers

7) Boundaries of Mobility: Visitors play a board game, which is equipped with multiple RFID tags (inside the pieces) and readers (beneath the board). During the game, videoclips are shown depending on the pieces' position on the board.

Fig. 11. "Boundaries of Mobility" with multiple RFID readers

B. *Projects with moving readers*

In contrast to the projects above, in the following cases the RFID reader is moving, while the tags are static.

1) Graz Fairy Tale Train: While the Graz Fairy Tale[6] train is on its tracks, audio is automatically played and interactive stations are switched on by default. The two locomotives are equipped with RFID readers and RFID tags are mounted along the trail. The whole timing can easily be changed by relocating the RFID tags or adapting the configuration files. The installed mid range readers have a antenna with the size of 30 x 30 cm and the reading range covers about a 50 cm radius around the antennas. The readers are mounted in a heigh of 20-30 cm above the tags. In order to increase the accuracy of the identification, we use 3-4 tags per station. However, if the trains are going too fast, the tags cannot be identified by the readers, because it is not possible to communicate with them in such a short time. The Graz Fairy Tale Train was realized in cooperation with the Graz Children's Museum FRida & freD.

Fig. 12. "Graz Fairy Tale Train" (© GMB – Hannes Loske)

2) Chrismas All Around The World: Christmas is celebrated different across the globe. RFID tags are hidden in a globe behind every capitol city. By pointing on the city with a pen-like RFID reader the visitors receive information about the Christmas traditions in the chosen country. This exhibit is current in development in cooperation with the cultural club "Blaues Fenster". In this application, we can identify spots on the interactive globe within 2x2 mm^2.

Fig. 13. Christmas All Around The World (demonstrator)

3) Coin Magnifier: Visitors use magnifiers to receive additional information about coins in the Coin Cabinet of the Universalmuseum Joanneum in the Eggenberg Palace in Graz[7]. Magnifying glasses, which are common in coin cabinets, are used to take a closer look at the coins, but they also act as an interface with the invisible computer. RFID antennas are built into the magnifiers and the RFID tags are placed beneath the coins. Therefore, customized antennas have been designed and built inside the magnifiers. This allows to show visitors further information on the screens without an additional interaction.

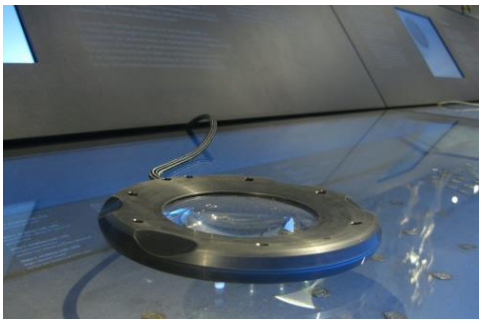

Fig. 14. Coin Magnifier with integrated antenna

[5] http://www.naturparke-steiermark.at/
[6] http://www.grazermaerchenbahn.at/
[7] https://www.museum-joanneum.at/muenzkabinett

V. Conclusion

The presented projects show that RFID technology can be applied in various use cases. The users interact with objects, without the need to know anything about the technology behind it. This allows an innovative and intuitive hands-on interaction to enhance digital media experience of exhibits in museums.

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