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Ubiquitous Computing for Augmenting the Learning Experience within an Urban Archaeological Tour in the City of Graz by use of an ArcheoApp for the iPhone

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Abstract: A particular problem for students of urban archaeology is that objects found at archaeological excavations have been removed to a museum or depot and the site is built over, thus no longer visible. Methods of labelling these sites and providing information about history and contents are available and should be made easily accessible using ubiquitous/mobile devices (e.g. iPhone, iPad etc.). We applied Radio Frequency Identification (RFID) first, however, the handling of both the transponder and the receiver along with a mobile device was technologically working, but had some usability disadvantages. Based on this experiences, we developed an application for an iPhone (iPhone App) and used Quick-Response Codes (QR-Codes) instead of RFID. The current ArcheoApp is developed to use it for learning purposes along a route of 13 points of interest for a lecture on urban archaeology.

Keywords: Urban Archaeology, iPhone App, Ubiquitous Computing, Smart Tags, QR-Codes.

Introduction and Motivation

In archaeology researchers deal with a lot of archaeological artefacts and features, which usually are described by information on separate pieces of paper labels. Although such labels are practical, information on paper has some limitations. Consequently, the support by electronic information is apparent. Originally, the idea of this project was to use radio frequency identification technology (RFID) for tagging archaeological objects. This was obvious due to the fact that we have past experiences with the application of RFID based technologies (HOLZINGER et al. 2010; HOLZINGER, SCHAUPP and EDER-HALBEDL 2008; WEIPPL, HOLZINGER and TJOA 2006; HOLZINGER, SCHWABERGER and WEITLANER 2005). For the first experiment we used a RFID-reader device (smartSCANN DY, see Fig. 1) along with a separate handheld device.

Although technologically working, it appeared to have lacking usability; i.e. to handle two devices simultaneously is awkward. Based on these experiences, we decided to use 1) a smaller device (iPhone) and 2) Quick-Response (QR-Codes) having the advantages of optical readable, i.e. functioning with any handheld having a camera. Currently nearly all mobile phones have integrated cameras. The goal was to support an urban archaeological tour in the context of a lecture held 2009 at the Institute of Archaeology in Graz (see Fig. 2). After getting to know the basic terminology of the current legal framework and historical development of the methods, the main focus of this lecture is an introduction to the current methods of practical archeology, in order of their application in the field. Taught is the "theory of practice", the basic

methodological approaches to prospecting, surveying, excavation, documentation, typology and chronology as well as age determination methods. Key issues are here for example in the aerial archaeology, scientific survey- and age determination methods as well as the stratigraphic excavation method, layers genesis and interpretation of findings. Practical exercises on selected topics (cartography, surveying, measurement, find documentation, photography) are included. The program is supplemented by field trips and field exercises at archaeological sites and open excavations in and around Graz. Based on the urban archaeological tour in the City of Graz 13 archaeological points of interest (POI) have been used.

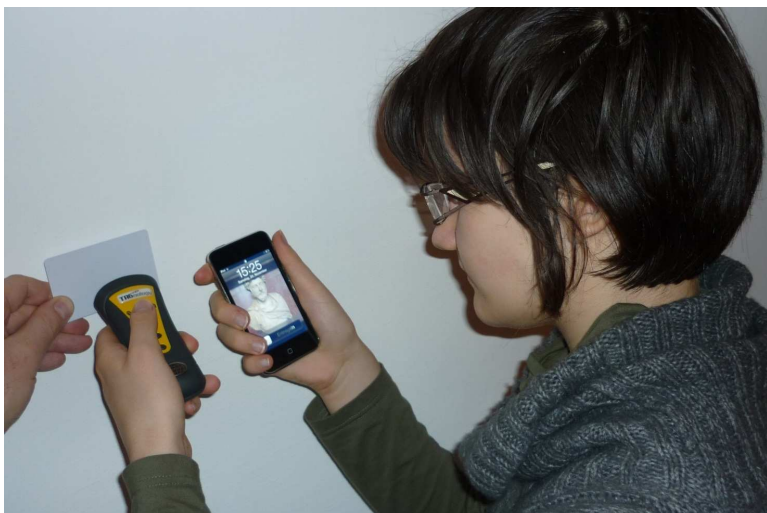


Fig. 1 – The SmartSCANDY device in operation (left), reading information from a RFID tag (we are grateful for the support of TAGnology, <http://www.rfid-center.at>).

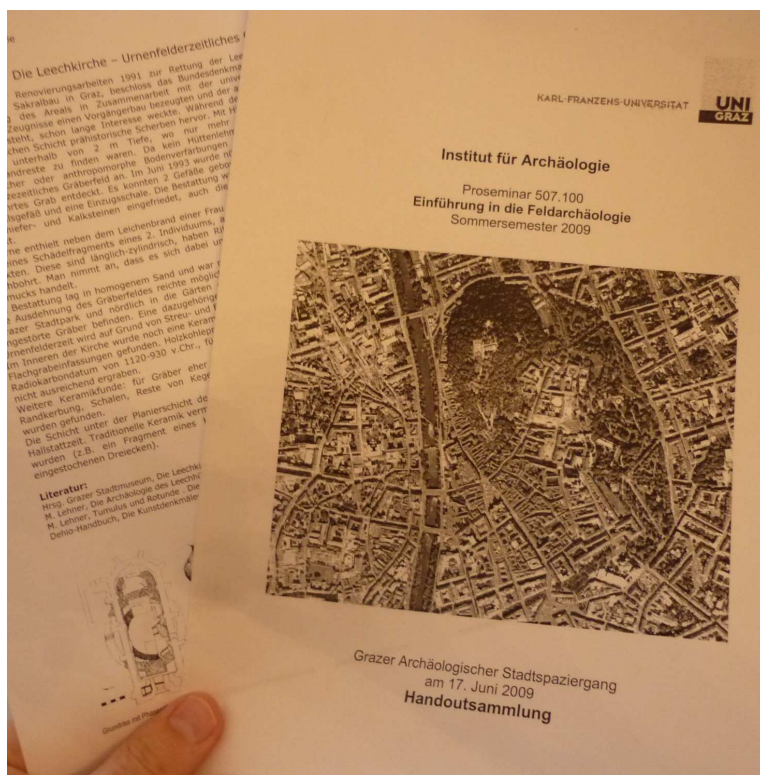


Fig. 2 – Paper based script of the Archeological City Tour, collection of 34 handouts worked out by students within the lecture of M. Lehner, Graz).

Selected points of interest (POI)

1. Leechkirche
2. Karmeliterplatz
3. Schlossberg
4. Reinerhof
5. Stadtmuseum
6. Admonterhof
7. Die Grazer Stadtmauer
8. Hauptplatz
9. Franziskanerkloster
10. Das frühmittelalterliche Gräberfeld / Alte Universität
11. Grazer Burg
12. Römersteine
13. Romanische Kirchen



Fig. 3 – Aerial view showing the 13 points of interest (M. Lehner, Graz).

Short archeological description of the 13 points of interest

1.) *Leechkirche*

This is the most important early Gothic sacral building in Graz. 1990 to 1994 the church and the church hill were archaeologically investigated by the Bundesdenkmalamt (BDA). Apart from two previous-phase round churches of the Romanesque style, it was shown that within the core of the hill an iron-age grave-mound is hidden, which was erected 600 BC on the area of a late bronze-age urn field (LEHNER 1996).

2.) *Karmeliterplatz*

In 1998 an early urn field cremation grave was found during restoration work within the yard of the former cloister (13th century BC). After all, this is the earliest documented grave of Styria (today in the Styrian country archive). At the Karmeliterplatz and in the adjacent Pfauengarten, archaeologists were able to secure findings of a gigantic fortified settlement of the Late Bronze Age and Early Iron Age during a 7000 sqm rescue excavation (April 2002 to August 2003). Today, nothing of both excavations is visible (HEYMANS 1999; KRAMER et al. 2004).

3) *Schlossberg*

This is an excellent example for the continuity of settlement. Findings are known from the late stone age until modern age, covering a range of 6000 years. Nevertheless, there were few regular excavations, because the whole suitable settlement area on the hilltop was covered by a castle in the Middle Ages (besides other, the residence of the Styrian margraves as the Babenberg Leopold V, who died here in 1194), which was destroyed by Napoleons' troops in 1809. Today most of the area has been built over (ARTNER 1997; KRAMER 2003).

4.) *Reinerhof*

In the course of renovations in the years 1992–1994, excavations took place, in course of which the "Stadthof" (first mentioned in 1164) of the Cistercian monastery Rein has turned out to be a late Romanesque "Saalgeschossbau", which in return has been marked on the modern façade. A large amount of finds was discovered including ancient roman, medieval and prehistoric pottery (KRAMER et al. 1995).

5.) *Stadtmuseum*

An emergency excavation took place as the City Museum of Graz was expanded in 1995 and 1996. It showed, that the area was used since the eleventh century. Basements and walls belonging to medieval buildings came to light. In fact the modern western Wall is set to a foundation which dates back to the thirteenth century. During the new architectural planning two early modern latrine pits have been integrated (KRASCHITZER 2004).

6.) *Admonterhof*

In the 12th Century mainly metal-working craftsmen settled in the place where, in the late 13th century, the Admonterhof (Stadthof the Benedictine abbey Admont) was built. Due to the fire risk, they had been pushed to the edges of the then existing castle's lower settlement, which entirely consisted of wooden houses. During the excavations in 2001 and 2002, necessary for the construction of an underground car park, 4 building phases were determined up until the 17th century, creating Admonterhof in its present form. Since the 1930s, it has been owned by the Kastner and Oehler storehouse (LEHNER 2004).

7.) *Die Grazer Stadtmauer*

When dealing with city archaeology, one can also see the constant change of time by looking at the city wall: First mentioned in 1265, it is not always possible to distinguish between the wall sections of the 13th, 14th and 15th centuries. Today, only a few of the fragments of the city wall still remain, all of them in later buildings, and the exact course of the wall is still unresolved (TOIFL 2003; LEHNER 2003).

8.) *Der Grazer Hauptplatz*

2001, large quantities of medieval material were found in the profile of a 38 m long trench. The subsequent excavation over several months provided evidence of a continuous settlement activity of today's Hauptplatz from the early 11th to the early 15th century. After small pit houses (semi-subterranean "Grubenhäuser"), there were two phases of timber buildings until, in the end of the 13th century, they were completely replaced by stone houses, which in their turn were removed around 1420 by the redesign of the square. A small part of the rich finds, including, besides the ubiquitous ceramic; glass vessels, coins, keys and tools is now on display in Hauptplatz, tucked away by the side-street to Davidgasse (STEINKLAUBER et al. 2002).

9.) *Franziskanerkloster*

A part of the Graz city wall was composed of the west wing of the earliest city monastery in Graz, built in the middle 13th century. However, the area had been already settled in the 12th century. In the 16th century there was a transformation, during which the city wall was demolished and a new building was erected. Between 1989 and 2010, five excavations by the BDA and the Institute of Archaeology have been carried out during construction (LEHNER 2009).

10) *Frühmittelalterliches Gräberfeld in der Alten Universität*

In 2003, 17 graves, dating from the 8th and 9th centuries AD, were found in archaeological investigations during construction on the university, which had been opened in 1585. 6 of the graves contained grave goods including pottery jars, rings, and headdresses and a small iron knife. The finds – unfortunately with limited accessibility for the public – are displayed at the locality in a corridor of the house Hofgasse 14. It is believed that there is an associated early medieval settlement in the area of Hofgasse / Freiheitsplatz, which, however, is not supported by findings (GUTJAHR 2007).

11.) *Die Grazer Burg*

In 1438, under Emperor Friedrich III, the construction of the citadel was started, which consisted initially of only two buildings: the main building and "Friedrichsburg" In 1500, under Emperor Maximilian I, the famous late Gothic double spiral staircase was built. Up until the 19th Century, there were many additions, alterations and demolitions of the medieval buildings. In the summer of 2010, in a short rescue excavation in the eastern wing adjacent to the Burgtor (eastern medieval city gate, the 13th century city wall was exposed, together with what are probably some high middle age warrior burials.

12.) *Die Römer in Graz (Römersteine)*

The two Roman stones in the stair tower of the Grazer Burg (castle) are from Flavia Solva and were placed at their current location during the time of Maximilian I. Another stone originating in today's Slovenia is located in the courtyard of the Palais Saurau in the upper Sporgasse. One can state the following about the Roman settlements of the within today's Graz city limits: The findings, which are mainly concentrated at

Schlossberg and in Strassgang, show evidence of a settlement activity from the 1st to the 4th century AD, especially in the peripheral areas of the "Grazer Feld". However, up until now, no Roman settlement has been excavated in Graz. An important indicator of settlement are the numerous burial mounds, according to which up to 30 settlement sites are presumed to be in today's municipal area (ARTNER 1997; KRAMER 2003; GRAZ IN FUNDEN 2003).

13.) Romanische Kirchen

The Romanesque style refers to a period from the 11th to the 13th century. Characteristic of this style are round arches, thick walls and small funnelled windows. The archaeologically explored Romanesque churches in Graz are: the Leechkirche, the chapel of St. Thomas on Schlossberg and the parish church of St. Peter; still unexplored sites include the Stiegenkirche, the Grazer Dom (Cathedral), the Rupertikirche, St. Martin, and the parish churches Strassgang, St. Leonard and St. Veit.

Related Work

Although there is some related work on the use and comparison of RFID versus QR-Tags, there is no such work available within archaeological education.

Osawa et al. developed a support system for outdoor learning using exploratory observation and conducted an experiment to use their system in nature observation. Their system used both RFID tags and QR-Tags to locate positions on a horticultural farm and its surrounding forests. They used a handheld computer along with a reader to detect the tags, where the students got a description and an educational hint. Additionally they used a mobile phone with a camera along with QR-Codes. Their evaluation showed that both RFID and QR-Tags were regarded as useful for outdoor learning by the students. The comparison of the two tag systems showed that the QR-Code was preferred, due to the easy handling with lightweight mobile phones (OSAWA et al. 2007).

A further work was presented by Chang et al. and describes a novel wayfinding system aiming to increase life independence of cognitive-impaired people (e.g. mental retardation etc.). They used geo-coded QR-codes which embed the coordinate (x, y, floor) along with a social computing approach to shorten the learning curve of the end user. For this purpose they attached geo-coded QR-codes which can be imagined as a new kind of traffic sign system to selected positions on routes. The navigational photos served on demand to the end user who uses the built-in handheld camera to take the QR-code when it is in eyesight range. A tracking function is integrated to timestamp the visited positions and issue alerts in case of anomalies. They also found QR-codes, in comparison to RFID sensor networks, as a cheap, easy and useful alternative tracking system increased which increased the sense of security and also lowers the entry threshold to accepting the assistive technology (CHANG et al. 2007). A general approach to tagging objects can be found in (GOH et al. 2007). Moreover there are examples of cultural mobile guides that put the end user and their need for mobility in the focus of attention (e.g. AUGELLO et al. 2006; PILATO et al. 2006) and there is some previous work which has been done on augmenting the learning experience in museums (e.g. HALL et al. 2006).

The ArchaeoApp Implementation

Based on the archaeological problem description in section 1, a concept for a mobile application has been created. In the beginning we thought on which platform the application should be developed. Besides of the increasing popularity, primarily due to the robust hardware equipment, the choice fell on the iPhone – or rather on the iOS platform, respectively. The iPhone has an integrated high resolution auto focus camera for an easy and precise capture of the used QR codes. Furthermore, the built-in GPS and the compass are also ideal for geo-location and thus suitable for navigation in the field. In the current version the app was implemented as a tab bar application in Objective-C, based on the iOS SDK 4.1. As our test device, we used an iPhone 4 with the current operating system iOS 4.1. The application also runs well on all models of iPhone 3GS series with the latest iOS versions. For the implementation of the software we made use of existing frameworks. For the recognition/processing of the QR codes, we used the Open Source Encoder ObjQREncoder by Jeff Verkoeyen, <http://mac.softpedia.com/get/Developer-Tools/ObjQREncoder.shtml>. For the geo-location and map view we used the already integrated framework "CoreLocation" and "MapKit". These two frameworks are not only for retrieval of up-to-date maps, we are also able to determine the position of the device on the map, i.e. the ArchaeoApp can also be used for navigation purpose. The archaeological information, described in section 1, is displayed in a so-called "Web View". In this view you can easily embed web content in the application. In our case this is done by using HTML code, having the big advantage that the content can be edited without much programming knowledge.



Fig. 4 – The ArcheoApp on geo-location "Leechkirche".

Conclusion and Future Work

Future work includes the implementation of three adaptive levels (learner, tourists, children) and a so called archaeological scavenger hunt (Schnitzeljagd in German). Consequently, the primary use for learners of Archaeology will be expanded to tourists and children on the basis of a game-based approach, in order to

raise awareness for cultural heritage. Such an archaeological scavenger hunt is similar to a geocaching experience (O'HARA 2008).

To date no work on implementation of an archaeological scavenger hunt has been reported, although there are a few museums mentioning the usefulness for education (see e.g. the American Museum of Natural History, who also provides a direction App, <http://www.amnh.org/apps/explorer.php>).

Massimi et al. point out that mobile computing enables a group to accomplish efficient fieldwork in teams that they once performed in isolation, over several trips, or not at all. Field researchers can deduce new information from findings they make while in the field, and apply it immediately to the situation at hand. This is especially important in fields where the time or resources to conduct several studies isn't available. This domain can be termed mobile collaborative problem-solving (MASSIMI, GANOE and CARROLL 2007).

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