QRchitecture

Stefan Zedlacher
Graz University of Technology
Inffeldgasse 10/2, 8010 Graz, Austria
zedlacher@tugraz.at

This paper summarizes the use of QR-codes in everyday architecture and urban environments. Moreover it examines the aesthetic value of these patterns for architectural use and introduces a project that adopts these codes for a spatial orientation and information system. The project combines the artistic and architectural use of QR-codes, establishes connections between virtual and real space and uses CAAD/CAM methods to produce QR-codes with a sense of beauty. Is it possible to use QR-codes as an offline and online information system and improve with it the inherent information of places in a building? Could we also insert architectural beauty in these codes?

Creative coding, information visualization, architectural computing, processing, user experience design.

1. INTRODUCTION

More and more quick-response-codes (QR-codes), those tiny little barcode like patterns, are involved in our everyday life. These are mainly used in the marketing and advertisement industries but they also cover areas of the urban environment and not solely limited to advertising and entertainment facilities. Instead facades, pavements or art galleries are even affected by these „technoid watermarks“.

2. ABOUT QR CODES

Originally QR-codes were invented in 1994 for the automotive industry by the company *Denso Wave*. As a company in the transportation, logistics and automated recognition business they thought about new tagging codes that could store much more information than the previously used Barcodes and EAN codes. Also the goal was to find “quick response” codes with a wide error tolerance. They were dropped very soon after their introduction and replaced by RFID tags and near field technology. They then somehow became open-source and as a result the standards were further developed. Today smartphones, with the use of their built in cameras as „barcode reader“ make it easy for users to scan QR-codes and get further information regarding a particular advertisement. The standard itself contains data from several sources such as address book, email, dates, URL, simple text and so on. Simple but efficient QR-codes distribute further information to the interested user while hardly disturbing the other consumers. This fact is somehow contradicted in its conspicuous use for architectural environments where QR-codes work often as “signs” (Venturi, Scott Brown & Izenour, 1997). Technically, this contradiction is not necessary because there is a wide variation in the QR-codes inherent “design”. We will take a closer look at this fact in the next section.

3. THE EVOLUTION OF SOME PATTERNED PIXELS

It is not incorrect to call QR-codes a typical, industrial product. Without bravado, often monochrome, with no flourish attached, it celebrates a revival in the field of marketing and advertisement. Placed in adverts, posters, websites and many other advertising environments (NoxiTech, 2012), they offer the ability to hide “second stage” information behind a pattern. A pattern that looks somehow technical, ordinary but also straight or banally designed.
Nevertheless, they have instigated a second evolution as „design codes“. The ability to do so comes from the simple technical requirements of the “origin”, to be highly error tolerant. To be error tolerant comes from the encoding method used for QR-codes, the so called “Reed-Solomon error-correcting codes”. The fact is that one could use 40% of the code for a logo, a picture or something else without losing the codes intrinsic accessibility. Moreover that could be found at *research!rsc* (Cox, 2012). Besides both offline and online Information that could be stored in the code, the image of the code itself could transport legible information. A vast number of examples could be enumerated. The “beecode” from the Swiss post is only one example. Its simple form and the pure pattern made it also appear as a Design product and

further more introduced it into the field of architecture.
In the design industry because it's in its origin, one could "overload" a product with information (they "look like" carrying information) by simply having a product looking like the code or the pattern. I would define these design product QR-codes as the third evolution of QR-codes.
Their use in architecture is different. Using QR-codes on facades, telling about the new campaign from XY over five stories height is the normal advertising use. But there are also examples like the N-project in Tokyo, Japan, where a QR-code on the facade is used to link the inside (the information about the inside) to the outside. Information about the stores and their products could be accessed through scanning the facade. Also an interactive, responsive system with the use of Twitter informs more about the building and its users. Compared to the hyperactive blinking BIX facade of the Kunsthaus in Graz, Austria, made by Realities United from Berlin, Germany, the N-project is a silent gesture. These two projects are based on the same principal idea, to connect the inside use of a building with the outside users and passers-by. The Kunsthaus uses a 255 bit per pixel, 930 BIg piXel on 900 m2 screen, playing converted QuickTime videos on the double curved "video wall". This, by the way, is seen best from the nearby rocky ground in the city center which one has to climb up. N-project uses only one QR-code.

There are not a lot of industrial (!) products that have a quality like the QR-code. But finally not all the varieties of QR-codes are developed yet. Recursive, telling, retelling or changing its storytelling and introduced in the simple use of analog game pads and laser engraving or used as space operating / space communication system is the fourth evolution introduced in its beginnings here.

4. OFFLINE AND ONLINE

What made QR-codes interesting for the use in our setup was the ability to store online, offline and human readable information at one time. How this is generally possible was explained in the previous section and how it is technically achieved will be explained in the next section.
But what does that mean to interior architecture? In the book "Orientierungssysteme und Signaletik" (Uebele, 2006) – besides other sources – the author point out a critical lack between the (interior) architects provision of spatial quality and usability and the graphic designers making the space accessible through their orientation systems.
From the architect's point of view, the space is self-explanatory and one must find ones way through by following the user's intention which is highly connected to the design idea. In the graphics point of view there must be a beautiful orientation system attached to the space. Otherwise you will not find your way. But what is the users point of view, the "user experience"?
The term *user experience* is widely known in the field of software design and less known in the field of architecture and design in general. User experience does not mean usability. *Usability* describes a value one could measure while "using" software or in the case of architecture using space. Form follows function is an example where usability is introduced to architecture. User experience describes not only the usage itself. It describes the *before* and *after*, the expectation of a product or software, overvalue one could feel after the usage, the reactions of users and so on. This could result from real usage but also from expected usage or the idea of the usage (EN ISO, 2010).

Architects trust in the hundreds of years old genetic program of humans using real world spaces. Graphic Designers trust in a more than one hundred year old program of an aesthetic overvalue. (This is referred on one hand to the beginning of the second industrial revolution and on the other hand to the term itself introduced by W.A. Dwiggins in 1922. Although saying this the cave paintings of Lascaux could also be seen as the first attempt at graphic design (Meggs, 1998).)
But information design these days changes rapidly these attitude turning out that both had to think about how we could "load" space and space accessibility with relevant – in our opinion furthermore localized – information. In other words if you find a space, what does it tell you about itself, its use, its history and its future tasks, its users and its things? And what is the way you get this information?

Jerp Thorpe at TEDx conference 2011 in Vancouver pointed out (mentioning location based services on Apples iPhone (Chen, Isaac 2011)), that we as the first party (and owner of the devices we use) have no access to our self-produced local data (second party is Apple, third party is the developer of the App, e.g. if an App XY asks: "Is App XY permitted to use your local data?"). The resulting project was *openpaths* (Thorpe, 2012) with the conclusion that we need a new, fundamental respect of our data in general. We think space information data (and we are not talking about geographical information systems (GIS) instead talking about real space in buildings) is also a hidden treasure that needs to be apportioned a certain respect. What is missing is the map to access it.
What we tried with this project is turning QR-codes into real space information maps. We are not talking about movement data or electronic tracking devices; instead we investigate human conditions,

space condition, events and qualities of things in space and the space itself.

5. QR CODE PRODUCTION METHODS

How did our QR-codes work, how did we tweak them in the right direction and what are the differences to the existing projects? Investigating the technical features of QR-codes, we took a closer look to the possibilities of storing every type of information in the code and linking this information to online resources like schedule, routes, 3D models and nice information visualization (McCandless, 2010). The workflow could be described with the following steps though they were sometimes not in this particular order or passed through this order several times.

5.1 zXing

QR-codes and its generating coding libraries like the one from zXing (ZXing, 2012) were used in this project. They offered in the first step a user interface (UI) to generate all sorts of QR-codes online and offline and an application programming interface (API) to integrate this encoding and decoding processes in other core components and languages (Processing, Java, Android platform, Flash) and provides modules for several other languages and frameworks (cpp, iPhone SDK, csharp, jruby, Actionscript). zXing is a Google code project and it is not limited to QR-codes. It also supports other Multi-format 1D/2D barcodes like UPC-A and UPC-E, EAN-8 and EAN-13, Code 39, Code 93 and Code 128, ITF, Codabar, RSS-14 (all variants), Data Matrix, Aztec ('beta' quality) and PDF 417 ('alpha' quality).

Figure 1: *Example from the first steps the design of QR-codes. (Kerstin Gruber).*

5.2 Photoshop

As shown in figure 1 and 2, the second step was the graphic design of the QR-codes. We did this in Photoshop testing the readability of the code with smartphones and webcams. For this we used the application *Processing,* consisting of a Java library and an IDE (Integrated Development Environment).

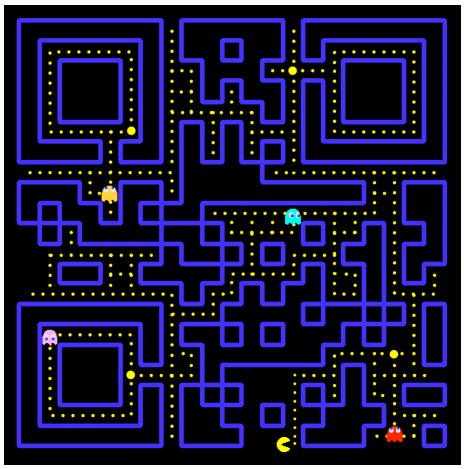

Figure 2: *Pacman design QR-code by a student (Susanne Kerndle).*

5.3 Processing

Developed by Ben Fry and Casey Reas (Fry, Reas 2001) as a simple interface to the Java graphics functions *Processing* was not only used to decode an encode QR-codes. We used it to generate the text to speech output, the “design-QR-codes” and the DXF/DWG files for manufacturing. Also we did the database access in Processing, we handled all the different formats of standard QR-code input (e.g. the four different versions of the vCard format) and we processed some HTTP requests and URL linking.

5.4 Manufacturing

Equipped with this toolbox the students were able to do a huge number of physical testing and experiments. Some of them were shown in figure 3. Thereof we got a lot of information about contrast, materiality, size and form of the pixels, layered styles, backgrounds, and many other aspects of the output shape of QR-codes.

Figure 3: *Examples from manufacturing the QR-codes (Armin Petzwinkler).*

5.5 Grasshopper 3D

Beside the physical output we were also interested in a virtual 3D output that was rendered. Therefore we used *Grasshopper* (Rutten, 2009), a visual programming interface module for *Rhinoceros 3D* software. It is developed by David Rutten at Robert McNeel & Associates and is still work-in-progress. But especially for students who are not common with programming languages, *Grasshopper 3D* offers an alternative to the common text based programming style. One could easily generate parametric geometry, in our case built on QR-code sources, from dragging and connecting nodes, components and Visual Basic scripts on a canvas with a real-time visual output in *Rhinoceros 3D*.

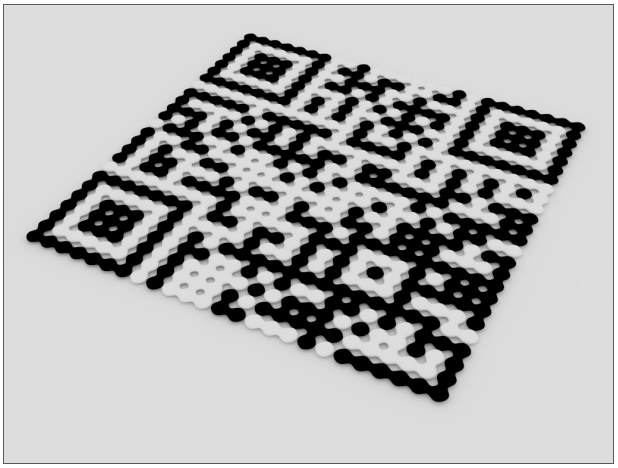

Figure 4: *Output from Grasshopper 3D (Markus Mayerhofer).*

Not ending at this point, we started to develop aesthetic experiments with the results of our observations and products. These experiments led us to the following projects.

6. PROJECTS

6.1 Charming disturbance

Charming disturbance on the one hand is a project about QR codes made of cardboard sheets which are transported through a building by its users. Gathering the way the code traveled through space (this is done with a online open source project by *jungidee.at* (Jungidee, 2012)), manufacturing the codes that they leave certain fingerprint and designing them in a semi-transparent polaroid format was all a part of the idea. Meanwhile these “polaroids” are not only used to transport underground information through the building of the university. It is also used for upcoming events (marketing) and as editable micro poster.

Figure 5: *Showcase charming disturbance.*

6.2 QRabe

With *QRabe*, we came up with a geo-localized project for archived architectural design data and connect this data with the QR code (hold in the beak of a raven). Theoretical (virtual) and historical projects from an online archive are connected to their real building sites in the town. Using QR codes was the key to connect the projects with the space. But introducing a semi-disturbing factor (the raven made of plastic) – normally used to disperse a primary disturbing factor (the pigeons in urban city areas) – is in fact the architectural (and artistic) intervention. Load the raven with some sort of digital content puts it not only in a new context. It provides high attention with common things and attracts to ask for answers one could get by scanning the QR-code.

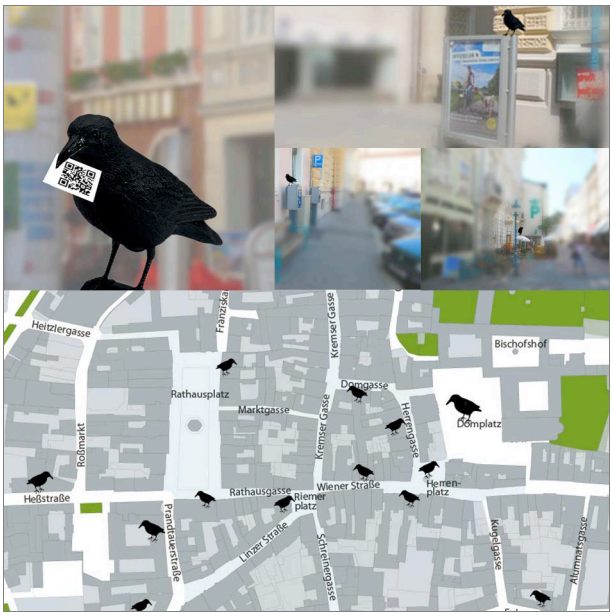

Figure 6: *QRabe – Accessing archived projects in the city centre of St. Pölten.*

6.3 Folding code

The third project in the row is a kind of folding-screen (figure 7) made for a one day exhibition in the Graz University of Technology. With this project we could explain what we call the aesthetic overvalue of digital improvements. The folding screen is used as „sign“ (Venturi, Scott Brown & Izenour, 1997) for the hotspots of the exhibition. This is necessary because the area of the exhibition is the whole university campus and we had to find a way to focus the visitor’s attention to some certain stations. Furthermore the QR-code provides information with text and spoken content (we therefore use a connection between the *Processing* software (Fry, Reas 2001) and Google text to speech (Google GTTS, 2011)). *Processing* is also used to generate the folding-screen elements. The manufacturing is fully automated (mass customized) where one uploads the information to a java applet and gets the DXF/DWG template file for an *epilog laser cutter*, based in the digital workshop of the Institute of Architecture and Media. With this workflow we could easily use different kind of material, proportions, size and information. Because the folding screen is an adaptive system we could have less or more information, link it physical by pairing connected QR-codes on their carrying panels and even add readable information to the inlays.

Figure 7a: *The Exhibition Information System – preview scene at day.*

Figure 7b: *The Exhibition Information System – preview scene at night.*

Figure 7c: *Parts of the Exhibition Information System.*

6.4 Operating space information

Finally we currently build a prototype for a space operating system in the University where QR-codes replace obsolete room numbers. QR-codes in this project handling both, online and offline space information and data of their equipment, furniture and surfaces. It connects things usually placed in the space, builds a timeline of the space usage and provides information of future use.

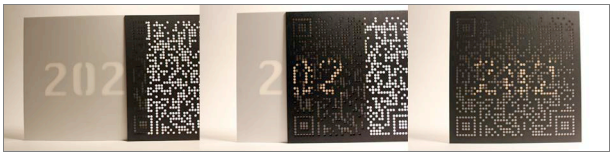

Figure 8: *Replacing room numbers buy QR-codes.*

7. STORYTELLING WITH THE CODES

When Janet Murray (Murray, 1998) talks about the „old days" of the online game "Zork" and other Multiuser Online Dungeons (MUD) she is offering us a new perspective looking at the non-linear, multistory way of building your own story inside a fixed frame. Generally all the digital, virtual technologies (from Web to Virtual Reality) offering a wide range of reading and telling your own story.
Much more further, *pervasive gaming* connects the virtual world to the real, within an underlying new thrill in the way using our elaborate gadgets (smartphones, pads, tabs, navigation systems) as way finder, extended compass and uplink to the storytellers of the game (Montola, Stenros & Waern 2009) .
But the question is: Why so difficult or in other words why so technically elaborated? When we started exploring the use of QR-codes, we were confronted with the "business stuff" like iCal, vCards, telephone numbers and Wi-Fi network access, GPS targets and short messages service (SMS). But, what does a good story or a fairy tale consist of?
Snow white gets an SMS from the dwarfs, she has a vCard, their hut in the woods could only be found with the proper GPS coordinates and "Once upon a time…" could also be translated into an iCal format. Who, what, when and where are the basic information even in the fairy tale. All translated into a single (QR-) code (or a folding screen), read by a computer voice from Google text to speech (GTTS, 2011) and imported directly into your calendar, address book or your map to „ …behind the mountains at the seven dwarfs".

8. COMMUNICATION WITHIN THE THINGS

What about an email newsletter System for a room? Let's think in another direction. When we talk about things in spaces we are not used in these things carrying a lot of information with them. But they do.
In our test scenario it was even simple to find one hundred datasets of information from a common office chair. Once collected, this information could be linked and distributed to each other "member" of the space. The things getting invisible connected and distribute information within each other. We would call this a *space communication system*. A visible connection of communicating things in space was presented in Aristotle's office (Keene, Kyprianou 2009).
But how could we do that without inventing the wheel once more new? We are now at a point where we use the QR-codes to monitor if things (and their information) are accessed and we distribute their information offline and online to the user (or scanner). We would like to give everything an email address and let them communicate with each other – monitoring and control it through an email marketing solution or a simple newsletter system.

What we tried to explain with our research in the field of digital media in architecture is that intelligent technology improvements must not be unavoidably separated from the usual architectural context like spaces, doors or furniture. But we could also use existing technology to realize prototypes that give us an idea about the experience with *intelligent furniture* or *self-confident space*. We think this approach gives us the possibility to attempt what we assume – without putting too much effort in the technical solution itself.
This is necessary because of the *user experience*. While new to software design and information technology in general, *user experience* is a very old and common task to architectural practice. Architects are used in design and re-design space several times, even if it is built. Residents are used in arrange and re-arrange their furniture and space usage. Both are used in demolish spaces, things and ideas if they do not fit to their expectations. The better we address the user experience with our technical improvements, the better these improvements will be accepted as part of the architectural experience itself.

9. CONCLUSION

If we talk about QR-codes in architecture we found them mainly in - let us say - large scale environments. What we found in our research is, the larger the application field (in these large scale environments) the more it is marketing and the less it is an architectural installation.
Therefore it is the small, space assigned area that could make QR-codes a design element that expands the primary information system of each

space (room), connects the real, physical space with its virtual counterpart and could be furthermore a newly designed element of space specification or space number.
Furthermore we described and constructed a toolset upon which some showcases were built. Students with fewer skills in programming and scripting could easily build their own descriptive system of connecting space, its information and its containing of objects. Based on *Processing* (with zXing library and Google text to speech we suggest the use of QR-codes as a representation of non-physical information in real space. No high-end screens with state of the art hologram technology will "mirror" or "augment" information to some glasses we have to put on.
However, cheap materials with state of the art prototyping technology (laser cutter on the hardware side, *Rhinoceros/Grasshopper 3D* and *Processing* on the software side) is also capable to transport a lot of digital, invisible information to the users of certain spaces. Last but not least we extended the "built the tools you use" approach in architecture to "use the materials you know".
Self-explanatory this is work in progress but as you can see we found some capabilities to introduce QR-codes in architecture in a new manner, connecting real world space with its digital information by simply connecting (and extending) exiting technology.

10. FUTURE WORK

All of that will disappear when QR-codes get less popular. Even the hope that this intelligent piece of technology (with its several states of evolution) will survive, no one could really argue that QR-codes are the key to a new information system. Nevertheless we tried to point out a "touchy" problem in augmented architecture: Most of the solutions connecting virtual and real space are driven by new, high-end and elaborated screen and vision technology and less taking existing technical evolutions and architectural qualities in account. The question at this point is not, what new kind of gadget could do some new crazy things (Lanier, 2010). The question is how we could implement the mass of information from existing space (and its components) to the existing space using architectural elements.
Palladio, the famous renaissance architect, did it by simply painting the walls of the Villa Capra "La Rotonda" with some scenes of what is happening in exactly that space. Others did it by attaching plaques to the main entrance of a building (often saying who paid for the project). We are thinking of using prototyping technology and architectural material knowledge to produce some *space intelligence* or *self-confident space* within the material it is made of.

11. ACKNOWLEDGEMENTS

Many thanks to Thomas Diewald for the programming support, Aidan Swanton for his graphic design input and Armin Petzwinkler beside other students from New Design University St. Pölten and the Technical University Graz for their project work.

REFERENCES

Chen, B. X., Isaac, M. (2011) Wired http://www.wired.com/gadgetlab/2011/04/iphone-location/ (23.4.2011)
Cox, R. (2012) http://research.swtch.com/qart (12.4.2012)
EN ISO (2010): ÖNORM EN ISO 9241-210:2010 (D) 2.15, Österreichischen Normungsinstitut, Wien.
Fry, B., Reas, C. (2001) http://www.processing.org (4.1.2012)
GTTS: http://weston.ruter.net/projects/google-tts/ (23.11.2011)
Jungidee (2012) http://jungidee.at/qr1 (20.3.2012)
Keene, T., Kyprianou, K. (2009) Aristotles office *Electronic Visualisation and the Arts (EVA 2009)*, London, UK, 6–8 July 2009, 285–288. British Computer Society, London.
Lanier, J. (2010) You are not a gadget: A Manifesto. Knopf, New York, NY
McCandless, D. (2010) Information is beautiful. Harpercollins, UK.
Meggs, P. B. (1998) A history of graphic design. John Wiley & Sons, New York, NY.
Murray, J. H. (1998) Hamlet on the holodeck. The future of narrative cyberspace. MIT press, Cambridge, Mass.
Montola M., Stenros J., Waern A. (2009) Pervasive Games, Elsevier Morgan Kaufmann, Amsterdam.
NoxiTech: http://notixtech.com/blog/27-ways-use-qr-codes (2.4.2012).
Rutten, D. (2009) http://www.grasshopper3d.com/ (21.2.2012)
Thorpe, J., et. al. (2012) https://openpaths.cc/ (2.3.2012)
Uebele, A. (2006) Orientierungssysteme und Signaletik. Führen - Finden - Fliehen. Schmidt (Hermann), Mainz.
Venturi, R., Scott Brown, D. Izenour, A. (1997) Zur Ikonographie und Architektursymbolik der Geschäftsstadt. Birkenhäuser, Basel.
ZXing: http://zxing.appspot.com/. (12.1.2012)