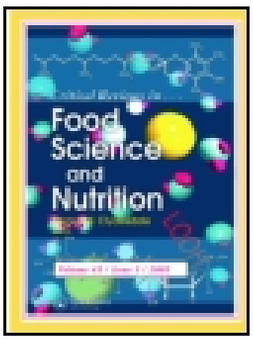

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Javier Sanz-Valero , Luis M Álvarez Sabucedo , Carmina Wanden-Berghe & Juan M Santos Gago

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QR codes: Outlook for food science and nutrition

Dr Javier Sanz-Valero (Corresponding Author)

Email: jsanz@umh.es

Miguel Hernandez University, Alicante, Spain

Dr Luis M Álvarez Sabucedo

Email: lsabucedo@gist.uvigo.es

Vigo University, Vigo, Spain

Dr Carmina Wanden-Berghe

Email: carminaw@telefonica.net

University CEU Cardenal Herrera, Elche, Spain

Dr Juan M Santos Gago

Email: Luis.Sabucedo@det.uvigo.es

Vigo, University, Vigo, Spain

Abstract

QR codes opens up the possibility to develop simple-to-use, cost-effective-cost and functional systems based on the optical recognition of inexpensive tags attached to physical objects. These systems, combined with Web platforms, can provide us with advanced services that are already currently broadly used on many contexts of the common life.

Due to its philosophy, based on the automatic recognition of messages embedded on simple graphics by means of common devices such as mobile phones, QR codes are very convenient for the average user. Regretfully, its potential has not yet been fully exploited in the domains of food science and nutrition. This article points out some applications to make the most of this technology for these domains in a straightforward manner. For its characteristics, we are addressing systems with low barriers to entry and high scalability for its deployment. Therefore, its launching among professional and final users is quite simple. The article also provides high-level indications for the evaluation of the technological frame required to implement the identified possibilities of use.

Keywords

Access to Information; Information Storage and Retrieval; Information Management; Information Systems; Health Communication; Food Sciences; Nutritional Sciences

Introduction

A Quick Response code (hereafter, QR code) is a mechanism designed to store information on a matrix of dots (a bidimensional barcode). This information accessed by means of a bidimensional arrangement enhances the storage capacity when compared with ordinary barcodes. These codes can store up to 7366 numeric characters or 4464 alphanumeric ones; thus, it is possible to reach 7 Kbytes on about 1 cm^2 (Dou and Li, 2008; Segatto et al, 2008).

The earliest beginning of the QR codes can be set on 1994 by a subsidiary enterprise of Toyota. The initial application was to support the administration of the inventory of items on the facilities of the company. But the apparition of software programs enabling the reading of these codes on mobile phones quickly spread the potential uses among the final users. As it is only required a minimum hardware to capture images, i.e. a digital scanner or a photo camera on a mobile phone or a tablet; the access to a broad set of information on the Internet is very simple and straightforward and, thus, possibilities for new applications with added-value for these users are brought into scene. Actually, the software to read QR codes avoids the need to manually introduce data on the mobile, thus, the user experience can be greatly enhanced. At a very high point of view, QR codes can be regarded as a link between the user and the data he/she is looking forward to accessing.

An aspect that benefits the expansion of QR codes is that, even being patented, they can be freely used as Denso Wave has chosen not exercise the patent rights (Denso Wave Incorporated, 2010). Therefore, it is possible to find a large number of applications freely available on the Internet to generate QR codes, including all the relevant and mandatory features (such as the square position

patterns on the corners of the image to detect the code) (International Organization for Standardization, 2006) (check figure 1) as well as many other features to make these codes more appealing to the final user.

It is quite common to generate QR codes including just a URL to make a straight access to the wished data by means of a data link to the Internet from the user device. This way, the user can access a wide range of resources ranging from web pages to multimedia contents without the need to previous knowledge about the content, without restrictions, at any time and from any place. Thus, it is possible to access to dynamic information that can be updated due to a number of reasons, by means of a static message on the "real world" that acts as a link between the user and the online resources. Reader may note that just a decade ago, most of the web content was static, i.e., it was not possible any kind of real interaction for web users. This is not true any more and the web has been redesigned to focus on boosting the collaboration of the users and the personal interactions (Sanz-Valero et al., 2012).

During these last years, in Japan and United States, these codes have been used for advertising and marketing purposes, to offer information to the customers about the product. A research conducted on this topic shows that 14 million users from United States aged between 18 and 54 had scanned QR codes on their mobile phones during June 2011. And even, surprisingly, 30% of tested consumers do not understand what was that "black and white hieroglyph" (comScore Incorporated, 2011).

In Europe, and particularly in Spain, the introduction of this technology is at a not so evolved stage. Nevertheless, there is a great potential as the 96,6% of the adult population (above 35

years old) has a mobile telephone enabled to use this technology (Instituto Nacional de Tecnologías de la Comunicación, 2011; Andrés-García and Okazi, 2012).

It is important to note that QR codes do not require the use of a plain, black and white matrix of smaller squares. On the contrary, these codes can benefit from the use of nicer colours or original designs that draw the attention of potential users. Actually, it has proved that the use of this kind of enhancements on QR codes increases the number of lectures about a 30% (The ACE Group, 2010). In a similar manner, it is possible to apply this sort of improvements not just to the code itself but also to its support to include them in new and unexpected contexts. This could bring into scene new application scenarios such as first aid situations (check Figure 2). From the ancient Egyptian, we can learn the valuable lesson of how to capture the curiosity of men by mean of the cryptography and codes.

The QR codes in the food science and nutrition

Although the use of QR codes is not fully exploited in the food science and the nutrition domains, it is possible to increasingly find them as complements and tags to food containers. Also, they are becoming popular as support for commercials on newsletters and posters to reinforce corporate images. It should not be overlooked the ludic aspect of the process to get the information: scanning the code, using/showing the brand new mobile and the "special" software installed on the smartphone, and, finally, discover the "hidden" message on the "magic square": discount coupon, recipes, download new applications, links to access online games, or even, show the physical location of the product manufacturer on Google Maps (Okazaki et al., 2012).

Its acceptance and main strength is based on completing the cognitive and behavioural attitudes (Shin et al., 2012), as proved by previous researching that concluded in a consistent manner that the social impact is a key factor in the adoption and use of new technologies. In this context, its application to new fields, such as food science and nutrition, seems to be of great interest. Actually, its usage in combination with other complementary technologies can be considered as promising (Flaig and Parzeller, 2011). And to release all these new possibilities, from the point of view of the user, the only required action is to launch the proper application on the mobile phone and point towards the QR code. In a fully automatic way, the information will be displayed on the screen of the mobile ready for its usage.

We can get a hint of how relevant this topic is becoming just by checking on Google Trends (check Figure 3). From these studies and the actual deployments on the industry, it follows that it is quite feasible to implement new proposals directed linked with the food science and the nutrition domains. The goal is to take full advantage of this new set of possibilities to disseminate information to the final user. Besides, if we are in position to link the information on this QR codes with scientific data bases related to food composition, drugs, food technologies, and related diseases; it would possible to create high-value services with very relevant information for final users that may turn out to be crucial to decide whether to buy or not to buy a particular product.

The main goal of this article is to show how this can be achieved. By using the Information and Communication Technologies (ICT) it is possible to boost these solutions and benefit the

transmission of knowledge in the domain. Among the already launched initiatives in this field the following can be outlined:

1. Proposals in the area of basic research
    - QR codes enable the complex tagging of samples in laboratories, allowing the storage and later gathering of large amounts of data. This procedure has been successfully tested on sequencing the DNA sequence symbology (Liu et al., 2012).
    - Gather material and research protocols. Researchers will use QR codes to collect sources of information or to complete the bibliographic part of their studies. This process may help colleges when checking the same sources of information.
    - Use of the high capacity of codes to avoid alimentary and drug frauds and falsifications (Meruga et al., 2012).
2. Proposal in the area of food security
    - Use of QR codes for food tagging in order to enable user to get all information about it; not just its nutritional composition, but also possible side-effects on his health or health plans (food suitable for celiacs, high energy product, content of certain sugars, minerals, fatty acids, additives or presence of certain allergens, etc.). This information could be customized using the user's profile.
    - Apply QR codes throughout the technological process control of foodstuffs (information protocols in the Critical Control Points), i.e., reports on compliance with food safety standards.

- Application in Hazard Analysis and Critical Control Points (HACCP) to fully support a food traceability protocol. This allows greater transparency for packed foods, as it can be identified the ingredients in a product, source, manufacturing, etc.
- QR codes can be used to provide detailed information about forward and backward traceability of food. Thus, it helps to improve the food security, in line with the guidelines from the European Parliament and Council (Regulation (EC), 2004).
- Report, through codes, quality certificates available for a particular food industry.
- Reduce time and costs in investigating food poisoning as the QR code will be linked to all records, processes and spatial coverage of the food.

3. Proposals in the area of community nutrition

- Use of codes in patient education. A QR code is an easy way to guide the patients to specific resources online.
- Using QR codes to promote health programs related to food science and nutrition among young people. These ones are undoubtedly the strongest advocates of the use of these technologies and, at the same time, the primary target of the epidemic of this century, the obesity.
- When purchasing vitamins and supplements, QR code allows to ensure that there is no contraindication to the use of regular medications.
- Healthcare services can use QR codes to provide patients the right information about their particular health issues (multimedia material for diabetics, celiacs, etc.).
- Information about foods that can be consumed on the basis of their individual health issues (obesity, hypertension, congestive real, etc.).

- The scanning and storage on the mobile device of the codes of the consumed food will facilitate the study of food consumption.
- Pharmaceutical products, and their advertising, can make use of QR codes to facilitate and improve the information about potential drug-food interactions (Lin et al., 2012).

4. Proposals in the area of Clinical Nutrition
    - A QR code added to artificial nutrition can be very useful to access to standardized protocols or to link to multimedia instructions with educational resources. For example, a cartoon video that teaches as parenteral nutrition should be administered through a catheter implanted (NADYA, 2011).
    - Codes can be linked to the prescription in all diseases, providing information such as the dates of issue of prescription, dosage, side effects, etc
    - The kitchen services in a health care institution can easily be aware of the specific menu of a patient undergoing therapeutic diet.
    - In home care, codes on food packages will facilitate the exchange of information between caregivers and medical equipment, especially in patients on enteral and/or parenteral nutrition.
    - In emergency rooms, QR codes can facilitate the identification and complete knowledge of the patient's medical history instantly.
    - Improve security in the exchange of clinical data(Chuang et al., 2010)
5. Proposals in the area of scientific documentation

- In meetings or conferences, attendees can scan QR codes to get more information about presented papers and the research groups working on the issues under consideration.
- Access to existing documentation in virtual libraries, providing support for reviewing scientific literature on the mobile device (Pan American Health Organization, 2011; CDC-Nut Group, 2012).
- Enhance information from an index of a scientific paper. A journal can send via a mail the references of published articles, attaching to each of them a QR code to access the full text of the paper.

Service Platform

Even all these service models are of great potential and interest, it is compulsory to provide these high level services with a particular technological support to be able to actually deploy the final services in a cost-effective and operative way. Fortunately, in the current state of the art, it is possible to address all required features in a standardized manner. Authors suggest a particular architectural infrastructure fully based on technologies endorsed and supported by international standardization bodies and freely available for practitioners. Thus, it is possible to obtain some inherent benefits such as open licence models, traceability of information at all points, use of different models from different providers and the corresponding interoperability with legacy and future systems.

As already mentioned, these systems draw their greatest potential when used in mobile scenarios, i.e., those contexts that are actually linked the final user and its actual context of the real life.

Therefore, average mobile phones or smartphones are the intended vehicle to access these services. To achieve an acceptable market penetration, it should be considered the use of frameworks such as Android (Collins et al, 2011) and/or iOS (Conway, 2011). According to the intended user of the application and its particular restrictions, it should be decided whether to use one of them or both. In any case, the interaction with the QR codes can be carried out by means of software libraries (already developed and available) that can be easily included in the prototype of the system. This software module will process the image from the camera in the mobile and extract in data embedded in the code.

At this point, it is important to underline the distinction between those system that store actual information on the QR code (they can work offline) or those that provide the user with an location identifier to eventually access to data (they usually require Internet access). The former are, usually, useful to post messages (ciphered or not) directly to the user. They are quite cheap as they do not require the use of data communication or a server to store information. Regretfully, their potential is quite limited and there are not suitable to most of the identified applications.

Those systems how access information on the Internet on the basis of the information gathered from the QR code are large more convenient to the purposes presented on this paper. On these systems, it is possible the use of Uniform Resources Identifiers (URI) to access the intended information from any standard software component; or it can be used some sort of internal identifier. These systems may use the data on the QR code to calculate some parameter or to establish some values, and, based on these results, decide which information exchange with a

remote server. Usually, more "software intelligence" is required for this kind of solutions and, consequently, it is possible to obtain services with a larger added value for the final user.

To make these complex systems possible, it is required to exploit a larger range of technologies as more features are involved. Nevertheless, it is possible to provide a full coverage for them without involving non-standard solutions. Still keeping the system free of platform dependences, an entire architecture can be provided as shown on Figure 4.

Once the QR code is processed, the resulting information is interchanged with a remote system to perform the required operations according to the corresponding business logic. It is suggested to undertake these operations using Web Services (Alonso et al., 2010). This middleware technology is not linked to any particular hardware/software provider, its implementation is free, and it is an official recommendation from the W3C.

Once the information has reached the server, it must be processed according to the needs of the system. The reader should note here that the information processing is usually expected to occur on the server. Thus, the user will be bothered with computational complex tasks or time-demanding process operations, as they will be carried out by the server.

As many proposed uses deal with medical information, it is suggested to pay special attention to how the information is exchanged and store/processed on the server in order to comply with legal regulation regarding sensitive information. It is suggested to make use of TSL connections (Dierks, Rescorla, 2008) supported by digital certificates issued by reliable certification authorities to ensure that the exchanged information is ciphered on secure grounds. This is possible in the suggested case of using Web Services to exchange data. These premises are of application regardless of the selected networks to interchange information with the mobile device (GSM, 3G, HSDPA, WiFi, …).

Final thoughts

QR codes will mean a revolution in the application of Information Technology and Communication to the food science and nutrition domains. The user will be able to gather information related to the nutritional composition of a food, discover if it affects her/his health, known about protocols in use, etc.

Also, practitioners of the domain will have a new tool to help in basic research, in the practice and the management of their business, in the field of community nutrition, and in their clinical practice.

This agile and accurate information on health history, allergies or contraindications will help decision making, being of the utmost importance in certain contexts such as emergency rooms. Also, duties related to processes and traceability of food production (such as how food is harvested, processed, packaged and distributed) may be driven more safely and efficiently. And this will clearly mean an improvement for all the society.

As we can see in the identified proposals, the potential use of QR codes on food science and nutrition are countless, almost anything developers and practitioners want to imagine is possible. So, sooner or later, in the author's opinion, all agents will have to tackle QR code technology. Also, it is not possible to overlook the mobile market and its overwhelming penetration, and this is possibly one of the best reasons to ensure the exploitation the potential within this proposal. These promising features make us believe that users will rapidly adopt this sort of solutions. Actually, despite being still in the early adopter phase, QR codes have all chances to become an interesting and popular application in the close future.

It is clear to the authors that professionals in food science and nutrition can not be oblivious to the new ways of disseminating knowledge. On the contrary, they should take an active aptitude towards its adoption and development.

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Figure 1: QR Code to access Critical Reviews in Food Science and Nutrition.

Figure 2: Collar that includes QR code with personal information

Figure 3: Graphic obtained from de Google Trends regarding searches about QR codes.

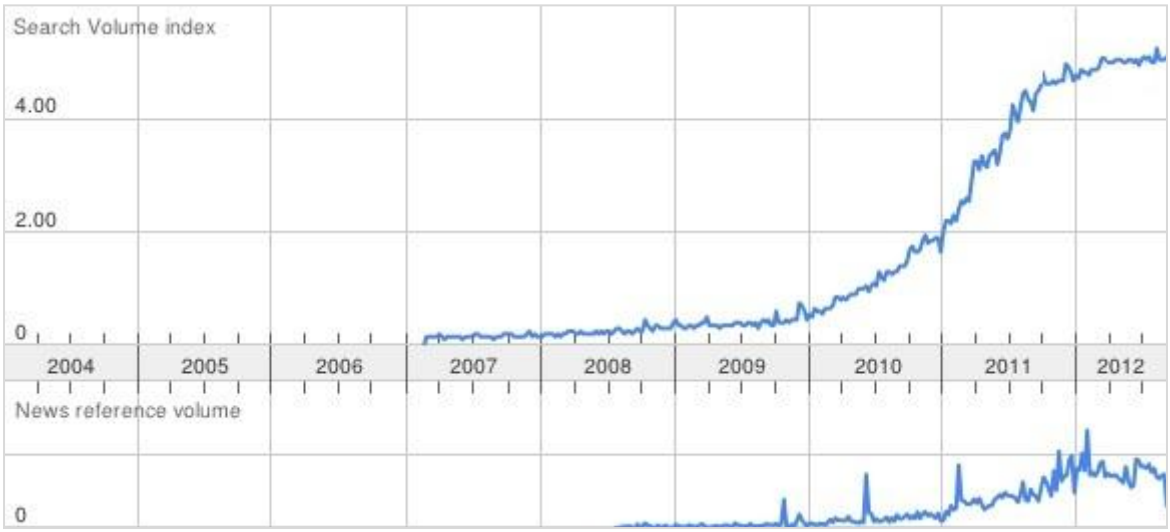

Figure 4: Architectural model for QR based systems