

ARTISTIC LANGUAGE OF CODED INFORMATION: THE PRINCIPLES OF VISUAL COMMUNICATION SIGNALS DESIGN

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Abstract. The coding of information considerably simplifies using of informational blocks and increases the need of revising of visual language formation that relates to people's perception. An improvement of aesthetic side of codes changes them into important element of visual communication. We consider the visual design of coded information from the position of the systemic approach, thus helping to involve people to communicate with the environment. For the first time in the study we revise coded information as a synthesis of mathematically programmed (metadata) and artistically designed components (code visualization). We prove that interaction of image, structure and context in creating of linear, two-dimensional and three-dimensional codes transforms them into an art work with a specific artistic language. As a result it becomes the powerful visual communication signal that can change the people's perception and behavior. We offer the algorithm for the visual coded information design, where associative, variational and adaptive principles are at the base of it. Their practical using outlines the perspective direction of the visual communication system development towards the versatility and is suitable to be used in different spheres of society.

Keywords: QR-code, bar code, visual communication, artistic image of the code, metadata.

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1. Introduction

Intensive using of communication and information technologies, their global spread and unlimited people's access to the Internet led to the increase of information amount. Nowadays usual informational messages cannot satisfy the growing needs of the modern society. In this regard the need of information presentation in a different way arose. It should be compact, easy to use and visually attractive for the consumer. Bar codes and matrix codes are perfect for these requirements. Today codes became extremely popular as information carriers on each product – from packages and outdoor advertising to clothes and landscape (Shumack *et al.*, 2013). However, for an average consumer it is just a set of incomprehensible black strips or spots that spoil the item look. That is why nowadays the actual problem is to find methods to make them visually attractive using color image embedding (Mittal, 2017). The code becomes an aesthetic visual signal that provides a quick response to visual information, image reading and interpretation and programs the subconscious perception.

People usually use bar codes and matrix codes only as technical object and attach importance of an information database – metadata. Lots of researchers are looking for reliable methods of QR-codes design on surfaces of different shape and curvature to get optimal parameters of their reading (Papp *et al.*, 2021; Qian *et al.*, 2021). The

improvement of metadata correctness without relying on the external mechanism of associations is an actual direction of research (Hill & Whitty, 2021).

Today processes of coding and decoding of information gradually move from the math-software side to the design of visual communication systems that depend on visual perception and receiving in-depth information from metadata. In latest researches related to the pandemic period, authors emphasize on the information communication relief due to the design of QR-stickers and posters that are based on the behavioral principles of expressiveness (Baugh *et al.*, 2021). Also, researchers use colorful components of images to increase the codes security level (Mathivanan & Balaji, 2021). Recently artists and researchers pay considerable attention to the codes decorating and improving of their aesthetic side using visual functions that go beyond their usual standard format (Yang *et al.*, 2019). There is a problem related to visual interpretation of coded information and the development of holistic concept of product design, where the bar code or QR-code images do not spoil the look of the item. Designers create visual look of codes to provide an instant identification of item or service and effective communication. In this case code plays the role of the separate visual element that has the advertising function. So, today hidden adaptive properties and undisclosed visual potential of the coded information become an important perspective direction of the visual communication design development.

2. Methodological framework

An aesthetic of contemplation, accessibility and versatility of visual language make it possible to identify the item or service quickly, transmit information more compactly and speed up the process of its perception (Shin *et al.*, 2012). It is important in particular for optimization of administrative services and regulation of the citizens' involvement (Lorenzi *et al.*, 2014), increasing the level of communication during surveys conducting and questionnaire (Fishbein *et al.*, 2019), etc. As a result, we see that the problem of the visual side of coded information development is tangential to processes of visual culture of the society forming. They are closely related to the science, machinery and technology development. That is why identifying of artistic language and designing principles in context of visual communication design is the aim of this research. We strive to focus attention on the following moments that will actualize the goal of the research step by step:

- the analysis of the bar codes and QR-codes correlation in the historical context;
- the emphasis on the multifunctionality of the look of coded information as a visual signal;
- the disclosure of the codes structure from the design positions;
- the revealing of the essence of codes designing methodic using means of artistic expression;
- the recommendations for the coded information designing in the context of the visual culture formation.

The system approach is the base for the methodological foundations of the study. We can consider the designing of the visual information content as a system phenomenon with its help. It forms the area for communication with the environment and a person and outlines the codes ability to adaptation and integration.

The important step of the research is the comparison of the structural and artistic features of bar codes and QR-codes. We use the comparative and historical method for this purpose. We traced the steps of the bar coding and QR-coding development in the historical context using this method. It points to the integration processes of mathematical methods of the information and artistic language formation in the integral design product. The evolution of QR-codes and bar codes works as the base for development of visual characteristics of coded information.

We use artistic-graphical, artistic-compositional, artistic-figurative design-analysis as research methods for the studying of codes' visual design and convenience of their decoding. We use the analysis of codes design samples from all over the world to reveal their composition features and explore the designing principles.

The finishing step of the research is the formation of the strategy of visual communication design using the prognostication method. The base of the visual communications is using of the coded information of different kinds. Such a methodological concept will cardinally change the perception of the visual communication design system and raise the visual culture level of the society to the qualitative new stage of development.

3. Bar code and QR-code: the evolution steps

People require lots of codes for storage of information and its spread. We can conditionally combine them into two types – bar code and QR-code. Their evolution is an important basis for the development of the concept of visual information design using comparative and historical method (Fig. 1).

The history of the bar coding invention begins in 1952, when Norman Joseph Woodland and Bernard Silver patented the system that reads information about product automatically (Kneese, 2014). The Morse code gave the impetus to the bar code creation. Bar code was visually the combination of black and white vertical stripes. It had one direction for scanning and informational volume of nearly 20 symbols (History of QR Code, n.d.). We can consider this period as the first evolution stage of the coded information that outlined the researchers' work on the math-software code structure.

Subsequently the information amount, which was coded with "usual" linear bar codes, became too small. Japan turned out in the vanguard of all the processes of the new approaches for the information coding search. Japanese researchers started to use "usual" bar codes for adapting them to the Japanese hieroglyphic script Kanji and the syllabic alphabet Kana (Rouillard, 2008). In 1994 famous Japanese machine building company called Denso initiated the project for the creation of a new coding mechanism for the visualization of technical information on details (Kneese, 2014). The team of engineers led by Masahiro Hara (History of QR Code, n.d.) elaborated new technology called matrix code or QR-code. Engineers presented absolutely new coding system – QR-coding. QR-code is two-dimensional bar code. People can scan it in two directions (vertical and horizontal) (Rouillard, 2008). In comparison with a bar code QR-code saves more data.

We connect the second evolution stage of coded information with approval of the code look. Coded information passed a long step of transformations to get the modern look. George J. Laurer designed the final variant of straight linear bar code IBM (subsequently Universal Product Code (UPS)) in 1972 (Smith, 2019). In return QR-code firstly got constant look: pixels that are closely intertwined (Smith, 2019).










Bar code	QR-code
I stage	Development the math-software code structure
1952 Joseph Woodland & Bernard Silver	1994 Masahiro Hara & Takayuki Nagai
II stage	Approval of the code look
1973 Linear bar code INTELLIGENT MAIL BARCODE  POSTNET 	2000 Pixel QR-code  DATA MATRIX  PDF417
III stage	Improving the code look aesthetics
2004 Appearance of additional artistic elements (Design Barcode, Japan) 	Early XXI Appearance of additional artistic elements 
IV stage	Coding dynamics
	2016 The first dynamical matrix code (Denso-Wave, Japan) 
V stage	Context designing
2010 creative bar codes in advertising 	2018 use of 3D matrix code 

Figure 1. Correlation of bar coding and QR-coding: evolution stages

The adaptation of codes looks through the associative approach happened in 2004, so the third stage of coded information development began. At this time Japanese design firm, called Design Barcode, made the bar code an original designing detail that did not lose its functionality (Rogers, 2009). In this way the bar codes designing turned into separate art and design industry named Barcode Art. Simple designing décor of matrix

codes in this period only begin developing. We can talk about the formation of the artistic language of coded information. We can relate it to the appearance of additional artistic elements in the codes look, e.g. color, gradient, background image, etc.

During the next stage of QR-codes evolution designers were looking for the coding dynamics. It contributed to the development of the visual communication design. In 2014 Japanese company called Denso-Wave designed the first dynamical matrix code named "FrameQR" (History of QR Code, n.d.). From the design point of view, it means that now the look of the code can change without losing the internal informativeness. This particular development became one of the reasons of the gradual development deceleration of mathematically programmed side of a bar code and intensive increase in a design development.

Nowadays we consider the coded information development as the possibility of the context designing. The improvement of the visual code component using design tools happens. It contributes to the appearance of additional elements in its look. At the same time matrix code actively interacts with the environment and provides the product modification. As a result, the transformation of the mathematically programmed product into the emotionally colored art work happens thanks to the intensive development of the artistic language of coded information. It points to the need of separation of code structural parts with the purpose of research of their creational features.

4. Structural features of coded information in the design context

Information coding is an easy way to connect virtual information and its materialized visualization to provide consumers with useful content. Codes have an organized structure that includes math-software (metadata) and art and design components. Together they create integral aesthetically expressive product (Fig. 2).

Mathematically programmed component or metadata is an informational database that is generated each time when people update information. We can see it after the code decoding. Art and design component and tools (e.g. color, text, image, silhouette, etc.) form the code look. Each consumer firstly perceives the look of the design development and only if the code attracts their attention, they will wonder about its internal filling. That is why, from the system approach point of view, the artistic language of the coded information activates the consumer's attention and motivates them to the communication. The integration of the mathematically programmed component and artistically designed components makes it possible to get the integrated design product that now people consider as the true art work.

Structural elements, such as image, structure and a context (Fig. 2), form the base of the code designing. Their interaction is important for the formation of the integral coded informational structure. The artistic image of coded information is a main visual signal for a viewer that can change the person's perception and their behavior. Material embodiment of the code look can be realized in two-dimensional or three-dimensional structures on the surface, volume and space (Skliarenko & Kalytiuk, 2020).

Bar codes and two-dimensional codes represent a code as a graphic element. People can embody coded information on the surface as a decorative spot or a certain image into a material object. Such codes are used in printing industry (e.g. for decorating of business cards, packaging, books, etc.) and in outdoor advertising (Rogers, 2009).

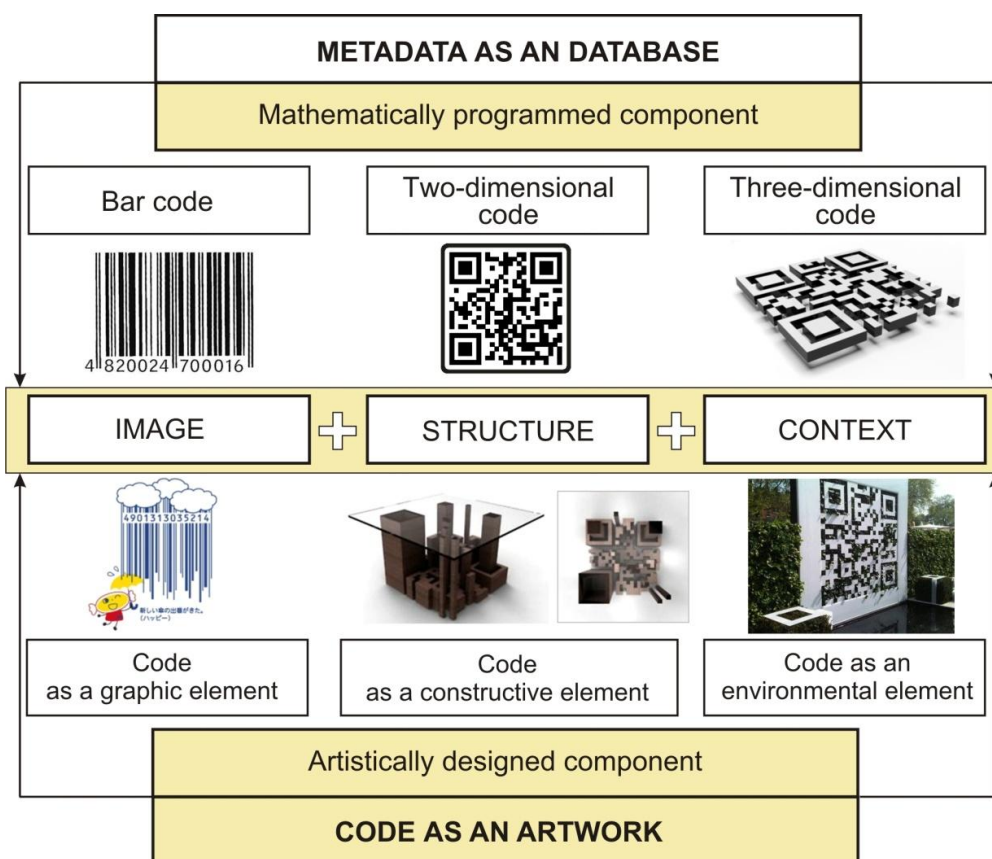


Figure 2. The structural formation of the coded information

Two-dimensional code can transform from the surface code to the volumetric one and hold its informational content at the same time. In this case we accept the visual image of a code as a constructive element. Expressiveness and clarity of perception depends on the code location in space and observation point.

A code image placed in specific environment changes its purpose under the context action. Such a method becomes more and more popular in architecture and landscape design. Code as an environmental element is created thanks to the deep-spatial transformations. It becomes an integral part of the visual communication. Nowadays, with the use of codes, people are stimulated to different actions. QR-codes act as dynamical and visual communications for the navigation based on game principles (Lorenzi *et al.*, 2014). In such a way, specific environment makes it possible to reveal new code properties and create original design ideas that will help to increase the ecological awareness.

We consider the context as an important means for the adaptation, integration and identification of a design object. Context provides coded information with different meanings. It characterizes coded information in three aspects: 1) as an informational essence (contextual QR Codes (Rouillard, 2008)); 2) as an art object; 3) as a tool of ecological awareness stimulation. Thus, coded information has a specific structure which clearly seen with interaction of mathematically programmed and artistically designed components. As a result consumer gets coded information as a multifunctional art work that is able to change thinking and behavior of people.

5. Creating principles of visual side of codes

People design visual part of code according to compositional laws that combine image, structure and context and create a harmonious work of art. We highlight three principles of code creation based on coded information analysis. These are associative, variable and adaptive principles. They are typical for the bar codes design, two-dimensional and three-dimensional codes (Fig. 3).

	ASSOCIATIVE PRINCIPLE	VARIABLE PRINCIPLE	ADAPTIVE PRINCIPLE
Bar code	Adding artistic elements 	Change of the information saturation of the image 	Multifunctionality 
	Interpretation 	Change of the image orientation 	Disguise 
Two-dimensional code	Creating code from separate elements 	Change of the code structure 	Transformation 
	Three-dimensional code		

Figure 3. The principle of the coded information creation

The justification of the associative principle is the part of image formation. People have some associations connected with functions, properties and ways of interactions with the environment when they see information about a product or service. Designers create the code image using associations that are based on different image forming. We can get creative images, based on the flat and three-dimensional coding, thanks to an addition of graphic elements that appear under the association action. Associativity is the

base of the artistic creation of linear codes. Adding an art element to the bar codes provides creation of new product content and makes it easier to identify (e.g. people associate juice with fruit, services in a restaurant with specific dishes, etc.). We can see a lot of these illustrations in different codes.

Using the associative principle to design two-dimensional codes based on an image interpretation with help of additional elements or color appearance. They complement a code visually and add new meanings to it.

People create three-dimensional codes from separate elements using combinations of different items. They base them on different associations of decoded information. People usually percept such three-dimensional codes as installation art.

Developing of creative code image using variable principle provides many variants of art changes. Variety of linear codes with different internal filling and visual look together form the only one narrative about an object. A great example is a method of bar codes repetition for the image of famous people creation (Rogers, 2009). People associate the life with the database that contains an infinite series of events. They show history of each object in such a mathematical way. Set of codes creates recognizable visual image with different level of informational saturation.

The change of the matrix codes orientation is also followed by its transformation in space or on the object. For example, in fashion design successful location of the code images at different angles determines by shapes, constructive elements and materials used in making process (Pashkevich *et al.*, 2018).

The variable principle helps to create a visual image based on structural code changes. It makes it possible to place codes on three-dimensional shapes of different curvature and construction (Yang *et al.*, 2019). Designing of QR-code images as three-dimensional structures, built into arbitrary shapes creates future potential for 3D-printed objects (Peng *et al.*, 2019). Constant improvement of 3D-printing methods improves the QR-codes efficiency using their visual features (Yang *et al.*, 2019). It makes it possible to identify and decode a code from different sides. E.g. Korean company called “Emart” place 3D-sculptures with a “Sun sale” QR-code in Seoul city. The structure of a “shadow” QR-codes series depends on the sun location and people can decode them only at noon. Successful decoding directs users to a special home page with store’s special offers. In recent years, the use of interactive “living” memorials (tombstones) with codes is popular too (Kneese, 2014).

Using the adaptive principle we can create a new code image by involving objects and processes in the environment provides. It makes possible to use the hidden possibilities of the environment to create new content and expand objects functionality (e.g. the bar code near a shopping center in Brazil becomes a pedestrian crossing and provides information about the discounts that apply to certain days (Rogers, 2009)). Ability of two-dimensional visual image of code to adapt to the environment appears through masking it. Actually, people can easily hide the code in any item, such as a logo, advertisement or a glass of Guinness beer. Accentuation on the main structural features is the base of the planer codes transformation into three-dimensional design objects. A promising future direction is the possibility of codes using to form the visual features of architectural structures. We can read code perfectly from different distances.

Using of associative, variable and adaptive principles in design expand the palette of the artistic language of the coded information and form effective signals of visual communication.

6. The practice of the using of coded information visual signals

With creative thinking people invent artistic and figurative solutions that make it possible to transform the software environment of coded information into artistic and mathematically programmed code into an artwork. In this case the process of coded information design becomes an important direction in the formation of a visual communication system. Visualization helps people to change the coded information environment consciously and make it look like a new design object (such as a tattoo or clothes with code elements).

As a result, the visualization of full volume of information occurs according to the following algorithm: code – association – visualization – artwork – visual communication (Fig. 4). The transformation of an ordinary data base (metadata) using the visual-imaginative language of coded information provides the appearance of a new design system, which people use in various spheres of social life. In this way, we program a person's behavior and capture their attention.

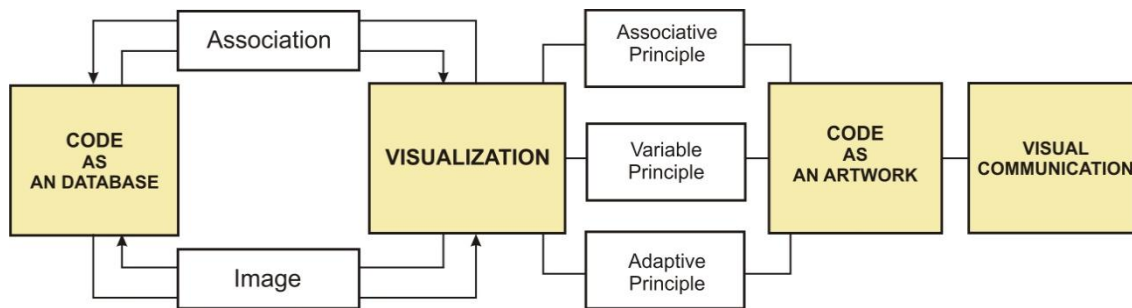


Figure 4. The algorithm of the coded information designing

The wide range of codes use (e.g. education, medicine, trade, production, art, etc.) requires rethinking of its design concepts and transformation of standard codes using artistic language. In this case the visual component becomes important in the communication context. We observe the development of coded information in the direction of universality. The expansion of the functional range and the introduction of environmental approaches to code design are its main manifestations. The widespread of matrix codes in the marketing industry and tourism is the evidence.

Nowadays coding becomes popular in external advertising that develops in some point between informational and not informational designing areas. People use artistic means to visualize advertising messages on billboards, public bus stops, and houses. They add dynamism to visual communications and increase the level of one's perception. Thanks to the rethinking of a code as a composition the possibility to involve the contextual environmental properties appeared.

The concept of the coding is closely related with web-design and dynamical identity creation. The identify feature is the ability of the object external characteristics using for giving consumers a big number of information in a concise and interesting way. Visualized coded information determines the nature of object perception in different areas of the people's life and variability of their using.

7. Conclusion

We consider the code as the symbiosis of information, visual image of the design product and living environment that is an integral part of people's thinking. Only such a systematic vision of processes of visual culture formation will provide a reset of human consciousness because namely visual communication design accumulates knowledge of various fields into the only one informational space and provides the qualitative indicator of communication in the environment and society.

We formulated the theoretical design aspects of artistic language of coded information. Structurally coded information consists of a data base (metadata) and its look that appears as a result of synthesis of artistic image, structure and context. Informational work of art forms as a result of data base integration and their look under the action of design thinking.

The awareness of the simple machine code as an art work makes it as a visual signal of communication. Creative design principles of coded information influence the consumers and force them to pay attention to it.

The main principles of bar codes and QR-codes design are associative (elements adding as the continuation of code image, metadata and object look interpretation and organization of separate elements for object look creation), variable (change of the information saturation of the image, change of orientation and change of the code structure) and adaptive (multifunctionality, disguise and transformation). On the base of compositional means used in the context of environmental features it becomes possible to program people's consciousness and their behavior in different spheres of life. Rethinking of design principles of coded information in a design context provides formation of the visual culture of the society. This publication outlines the development of the coded information visualization using design methods in a direction to the versatility.

References

- Baugh, J.J., Oran, R., Roberts, T., Hankin, M., Moore, K., White, B.A. (2021). The QR code: A treatment for COVID-19 information overload, *The American Journal of Emergency Medicine*, 45, 613-614. <https://doi.org/10.1016/j.ajem.2020.11.065>
- Fishbein, J., Lau, K., Barone, S. (2019). Quick response (QR) codes are a more effective means of eliciting feedback from patients and families, *Academic Pediatrics*, 19(6), e22. <https://doi.org/10.1016/j.acap.2019.05.060>
- Hill, G.N., Whitty, M.A. (2021). Embedding metadata in images at time of capture using physical Quick Response (QR) codes, *Information Processing & Management*, 58(3). <https://doi.org/10.1016/j.ipm.2021.102504>
- History of QR Code (n.d.). Retrieved from <https://www.qrcode.com/en/history/>
- Kneese T. (2014). QR Codes for the Dead. The Atlantic, *Technology*. Retrieved from <https://www.theatlantic.com/technology/archive/2014/05/qr-codes-for-the-dead/370901/>
- Lorenzi, D., Vaidya, J., Chun, S., Shafiq, B., Vijayalakshmi, A. (2014). Enhancing the government service experience through QR codes on mobile platforms, *Government Information Quarterly*, 31(1), 6-16. <https://doi.org/10.1016/j.giq.2013.05.025>
- Mathivanan, P., Balaji, G. A. (2021). QR code based color image stego-crypto technique using dynamic bit replacement and logistic map, *Optik*, 225. <https://doi.org/10.1016/j.ijleo.2020.165838>
- Mittal, A. (2017). Generating visually appealing QR codes using colour image embedding, *The Imaging Science Journal*, 65(1), 1-13. <https://doi.org/10.1080/13682199.2016.1241941>

- Papp, G., Hoffmann, M., Papp, I. (2021). Improved Embedding of QR Codes onto Surfaces to be 3D Printed, *Computer-Aided Design*, 131. <https://doi.org/10.1016/j.cad.2020.102961>
- Pashkevich, K., Yezhova, O., Kolosnichenko, M., Ostapenko, N., Kolosnichenko, E. (2018). Designing of the complex forms of women's clothing, considering the former properties of the materials, *Man-Made Textiles in India*, 46(11), 372-380.
- Peng, H., Lu, L., Liu, L., Sharf, A., Chen, B. (2019). Fabricating QR codes on 3D objects using self-shadows, *Computer-Aided Design*, 114, 91-100. <https://doi.org/10.1016/j.cad.2019.05.029>
- Qian, J., Xing, B., Zhang, B., Yang, H. (2021). Optimizing QR code readability for curved agro-food packages using response surface methodology to improve mobile phone-based traceability, *Food Packaging and Shelf Life*, 28. <https://doi.org/10.1016/j.fpsl.2021.100638>
- Rogers, S.A. (2009). Crafty Consumerism: 15 Creative Forms of Barcode Art. Retrieved from <https://weburbanist.com/2009/10/26/crafty-consumerism-15-forms-of-barcode-art/>
- Rouillard, J. (2008). Contextual QR Codes. Proceedings of the Third International Multi-Conference on Computing in the Global Information Technology. ICCGI 2008. July 27 – August 1, 2008 – Athens, Greece. IEEE. Retrieved from http://jose.rouillard.free.fr/perso/publi/2008_Rouillard_ICCGI.pdf
- Shin, D.-H., Jung, J., Chang, B.-H. (2012). The psychology behind QR codes: User experience perspective, *Computers in Human Behavior*, 28(4), 1417-1426. <https://doi.org/10.1016/j.chb.2012.03.004>
- Shumack, K. A., Reilly, E., Chamberlain, N. (2013). QR Code Mania!, *Strategies*, 26(3), 9-12. <https://doi.org/10.1080/08924562.2013.779851>
- Skliarenko, N.V., Kalytiuk, M.S. (2020). Forms of coded information visualization. *Les tendances actuelles de la mondialisation de la science mondiale: collection de papiers scientifiques «ΛΟΓΟΣ» avec des matériaux de la conférence scientifique et pratique internationale*, 3, 106–107. Monaco, Principauté de Monaco: Plateforme scientifique européenne. <https://doi.org/10.36074/03.04.2020.v3.33> [in Ukrainian].
- Smith, H. George Laurer, an inventor of the modern bar code, dies at 94 (2019). Retrieved from https://www.washingtonpost.com/local/obituaries/george-laurer-an-inventor-of-the-modern-bar-code-dies-at-94/2019/12/10/75b03f6e-1b5c-11ea-8d58-5ac3600967a1_story.html
- Yang, J., Peng, H., Liu, L., Lu, L. (2019). 3D printed perforated QR codes, *Computers & Graphics*, 81, 117-124. <https://doi.org/10.1016/j.cag.2019.04.005>