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Using QR codes as the target for augmented reality applications

STEFAN ĐURĐEVIĆ[1], DRAGOLJUB NOVAKOVIĆ[1], ŽELJKO ZELJKOVIĆ[1], ALDIN OBUĆINA[2]

1 FACULTY OF TECHNICAL SCIENCES, UNIVERSITY OF NOVI SAD, DEPARTMENT OF GRAPHIC ENGINEERING AND DESIGN, NOVI SAD, SERBIA
2 FACULTY OF TECHNICAL STUDIES, UNIVERSITY OF TRAVNIK, TRAVNIK, BOSNIA AND HERZEGOVINA

ABSTRACT

Augmented Reality is a new technology which uses mobile or stable device cameras to enrich the real world with computer-generated content. To make the connection between real and computer-generated world, it is necessary to correctly read the Image Targets and link the coordinate systems of the real (camera recorded) and imaginary computer-generated content. This paper presents a method of using the generated QR codes as Targets for augmented reality applications. The study shows different QR code readability results in various reading angles. The analysis of the results obtained to determine the influence of the type and number of entered characters, QR codes resolution and colour on their readability in augmented reality applications has also been conducted.

Keywords: augmented reality, readability, QR codes.

Introduction

At the beginning of their use, bar codes exclusively served for facilitating the sale of goods, informing quickly about the product price, the situation on the stock and the origin country. Developing technology and the rapid way of life have created the need for a faster and easier way of getting information.The expansion of smart mobile devices has led to an increase in the possibility of using barcodes and their development into the so-called two-dimensional barcodes.

Today, the most popular barcodes in this group are QR codes (Quick response codes) whose application, among other things, found a place in the marketing industry. The most common application of QR codes is that after scanning them, they load a website or a text content if there is no space for it in the area occupied by a single QR code.

Further development of technology brought augmented reality, which can be applied as a form of information for advertising or even in education. Augmented Reality is a technology that uses mobile or stable devices cameras, and enriches the real world by computer-generated content. Combining QR codes and augmented reality gives us different features, but in today's world of smart mobile devices, the combination of these two technologies can be applied in various ways. An example of applying augmented reality in a smart mobile device (Figure 1).

Figure 1: Augmented reality application informing about the contents of the location

Displaying augmented reality is carried out by proper mobile or desktop application which must contain the camera and display. The application works on the principle of detecting markers that are used as the basis for setting up a computer-generated coordinate system through which the augmented reality will appear. This paper explains the use of QR codes for augmented reality tracking markers.

Problem identification

In the experiment, QR codes were applied as augmented reality targets which were scanned with a mobile Android device using the device camera. Then, using the augmented reality application and based upon the target, a 3D cube shape representing the augmented reality content will be formed. The scanning process is performed at different angles and a fixed measuring distance from the QR code being displayed on a computer monitor.

To generate QR codes, a program called Barcode Generator has been used. Once the codes are generated, they are placed on a website called Vuforia developer to test the rate of their applicability for augmented reality targets. A programme called Unity has been used to generate the augmented reality application. Using Unity, a 3D object (cube) has been created and placed at the scene along with the Targets - 2D objects or QR code images in a square shaped .jpg format. The application has a total of 24 targets (QR codes) in many variations, and each is set in such a way that a 3D object (cube) appears in front of each target when read by an (Android device) camera.

Methods and tools

For the purpose of this experiment, a mobile phone Samsung Galaxy S5, computer monitor Samsung SyncMaster T220 and the device for mounting a mobile phone with the ability to adjust the angle in relation to the monitor screen from which the codes are read, were used (Figure 2). The monitor was used to display targets (QR codes).

After mounting the mobile phone in the cradle and placing the monitor in the proper position relative to the phone, the augmented reality application for reading QR codes and generating augmented content has been started.

The measurement of each code was performed in several ways. By continuously rotating the device for adjusting the measurement angle from 90 ° to 180 ° and rotating it from 90 ° to 0°, all the while tracking the point in which the 3D object disappears from the phone display. In addition to this mode, another test, i.e. measuring the appearance of the 3D object when the device is continuously rotated from 0 ° to 90 ° and from 180 ° to 90 °, was conducted. This way of measuring determined the angle degree up to which the app will be able to display the 3D object in relation to the type of QR code. QR code reading in augmented reality application works on the principle of target location memory. If the code has already been scanned, 3D objects will keep running even after the sharp position of the mobile camera causes the loss of target image, or if it is partially covered, because the shape found at the site of the lost code will be treated as the target image for a while.

The 3D object will appear when the camera lens is covered and then uncovered, even though the scanning angle of the camera position in relation to the monitor changed in the meantime and regardless of whether it is just the memory retention of the QR code position, no longer readable under the given angle. The research was conducted in this way to determine the stability of the 3D object generating regardless of the change in angle due to interruption of the visual line between the camera, the target, and readability of the code. It should be noted that the laboratory, where the experiment was conducted, had indirect natural light.

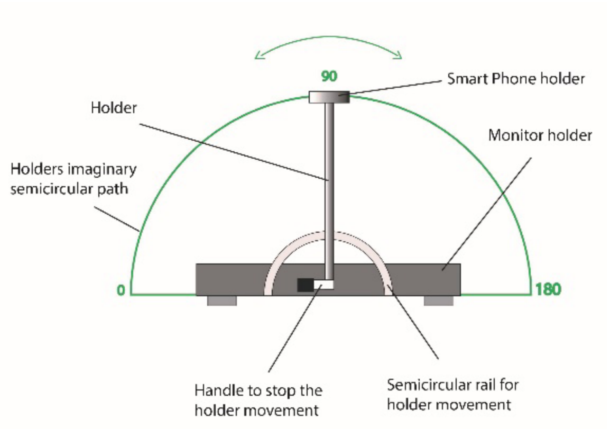

Figure 2: Equipment for mounting the mobile phone with the ability to adjust the angles

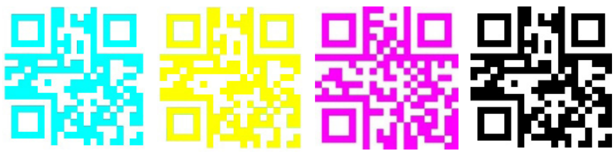

Figure 3: An example of generated QR codes

The tested QR codes are sorted into groups based on the character types (alpha or alpha-numeric), all the codes had the same number of characters (six characters), resolution (200px, 300px, 500px), and the cyan, magenta, yellow, or black colour. Examples of QR codes generated by the application are shown in Figure 3.

Results

The experiment was carried out on all generated QR codes divided into groups based on a combination of resolution, colour, the number and the type of entered characters. Twenty four QR codes were measured which generated a significant number of results. QR codes were specifically generated at the resolution of 200px, 300px and 500px, in black, cyan, magenta and yellow colour, with six alpha and alpha numeric characters that were entered. Measuring was conducted for 3D object disappearance at an angle less than 90o, 3D object disappearance at an angle greater than 90o, appearance of the object at an angle less than 90o, appearance of the object at and angle greater than 90o, as well as disappearance of the object at angles that are smaller or greater than 90o, due to breaks of the visual line between the camera and the QR code.

Table 1: Research results for QR codes containing six alpha and six alphanumeric characters

QR codes	Disappearance at an angle less than 90°	Disappearance at an angle greater than 90°	Appearance at an angle less than 90°	Appearance at an angle greater than 90°	Covering the lens at an angle less than 90°	Covering the lens at an angle greater than 90°
6 alpha 200px	5	170	55	125	35	150
6 alpha 200px Cyan	10	170	60	122	30	157
6 alpha 200px Magenta	7	170	50	127	30	150
6 alpha 200px Yellow						
6 alpha 300px	5	173	50	127	10	170
6 alpha 300px Cyan	5	173	50	127	7	140
6 alpha 300px Magenta	7	175	50	130	10	140
6 alpha 300px Yellow	7	172			15	165
6 alpha 500px	3	172	50	133	7	170
6 alpha 500px Cyan	5	172	50	117	7	172
6 alpha 500px Magenta	5	172	10	120	5	172
6 alpha 500px Yellow						
6 alphanum 200px	7	172	55	120	25	120
6 alphanum 200px Cyan	10	165	60	120	22	150
6 alphanum 200px Magenta	7	170	55	110	25	150
6 alphanum 200px Yellow	20					
6 alphanum 300px	5	172	47	125	10	167
6 alphanum 300px Cyan	7	172	55	122	10	160
6 alphanum 300px Magenta	5	172	52	120	12	165
6 alphanum 300px Yellow	15	167	90		25	120
6 alphanum 500px	7	172	55	100	7	135
6 alphanum 500px Cyan	7	172	60	120	45	135
6 alphanum 500px Magenta	7	172	68	112	40	135
6 alphanum 500px Yellow						

Table 1 shows the results of measuring QR codes containing six alfa and six alphanumeric characters. Interpretation of the graph is carried out by comparing the height lines representing the specified measuring method have while conducting the experiment. Each line colour represents a different measurement method and does not have the same interpretation. The dark blue line referring to the disappearance of a 3D object at an angle less than 90 ° is observed in such a way that it should be as short as possible, i.e. that it represents small numerical values of the angle. The red line is the disappearance of a 3D object at an angle greater than 90o, and it should be as high as possible to represent greater numerical values of the angle.

Discussion

Figure 4 is formed using table 1 values for the purpose of visual representation and comparison of the measurement results.

The green line represents the return measurement, i.e. reappearance of the 3D object at an angle less than 90 ° and it also has to be as short as possible so as to represent small numerical values of the angle. The purple line represents the return measurement, the reappearance of a 3D object at an angle greater than 90 ° and it is important that it is as high as possible so as to represent the highest possible numerical values of the angle. The light blue line represents the measurement results with visual line interruption between the camera and QR code for angles less than 90°, so it is necessary that these lines are as short as possible and represent the least numerical angle value. The Orange line also presents the results of measurements with the visual line break, for values greater than 90 ° and for this reason it is important that it is as high as possible and that it represents the highest possible numerical values of the angle.

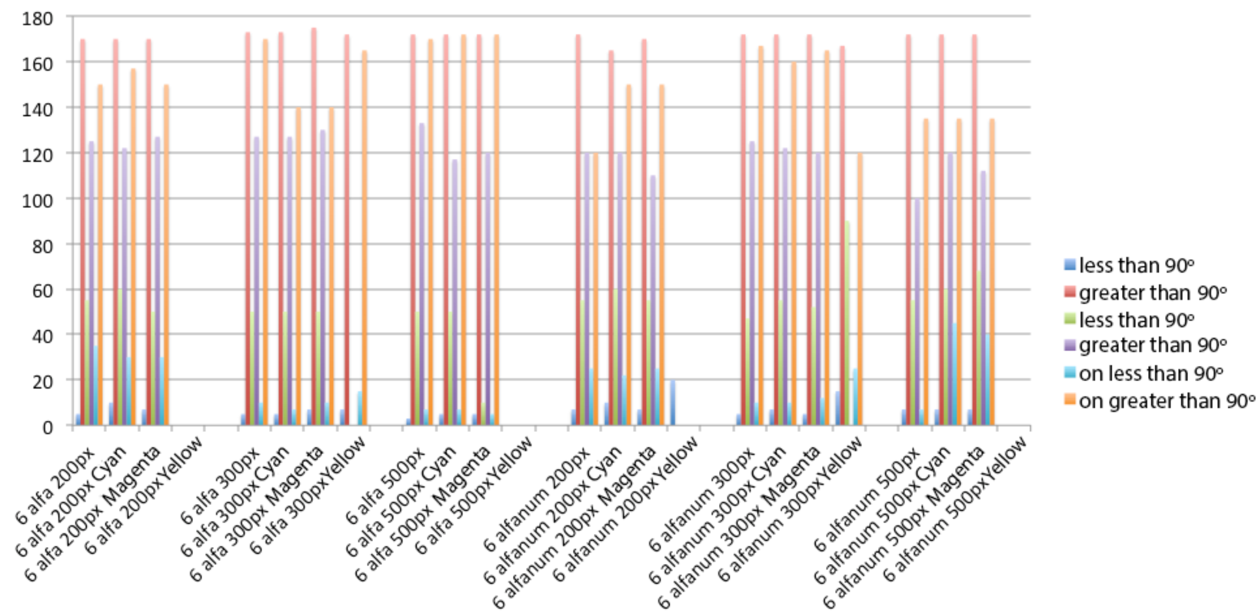

Figure 4: A graphic display of measurement results for QR codes with six alpha and six alphanumeric characters

What can be concluded from the review of the first segment from Figure 4 is that all QR codes are found readable when rotating the camera at angles greater than 90°, or more precisely, all augmented reality content disappeared only when the camera reached the angle greater than 160°. However, attention should be paid to the results of yellow QR codes because they have been found extremely unreadable at each measurement, and the 3D object appeared randomly. In this result division, when measuring the 3D object disappearing at an angle less than 90°, it was found that the QR codes with a resolution of 500px and six alpha character proved to be the clearest and managed to keep displaying the 3D

object under small angles (about 5°). In the reverse measurement, by moving the smartphone camera from zero degrees to 90°, it has been found that the QR code with the resolution of 500px and six alpha characters under the lowest angles generate a 3D object, specifically at angles which range between 40° and 50°.
During the camera return movement from the initial angle of 180° to 90°, the 300px resolution and 6-alpha character QR codes proved the best. The common occurrence of a 3D object was at angles around 130o. During the measurement conducted with the visual line break between the camera and the QR code at an angle less than 90°, the most readable QR codes were those with a resolution of 500px and six alpha characters. They were found readable in these conditions, at an average of 5°.
By measuring the visual line break between the camera and the QR code under an angle greater than 90°, the 500px resolution and six alpha characters QR codes with angles at about 170° proved the best.

Conclusion

By examining the influence the number and type of characters entered have on QR code readability in the augmented reality application, samples containing six alpha characters and a mixed alphanumeric content, were compared. The impact of the resolution on QR code readability is established by comparing samples that have been generated in 200px, 300px and 500px resolutions. Based on the measurement results, it was concluded that 300px and 500px resolutions are optimal for generating QR codes because they guarantee their proper readability in augmented reality applications. The Samples of 200px resolution QR codes are readable, but the results vary depending on the method used to measure the reading angle, as well as character types. The 300px 500px resolution QR codes have proved to be clearest whether containing six alpha, or alphanumeric characters.

By examining the impact of colour on QR code readability, a basic rule for all the barcodes has been established. There must be a high contrast between the background colour and the colour of the barcode. QR codes can be, not only in black, but also in other colours. However, one should certainly follow the rules of high contrast between the background and the code colour. The examined QR codes are generated in black, cyan, magenta and yellow colours with different resolutions and character types. The comparison was made so as to reach a conclusion on the impact the resolution, type of character and colour have on QR code readability. The comparison of QR codes containing six different types of characters shows that magenta coloured QR codes have the best readability regardless of the resolution and type of character.

Better readability of QR codes was also noted in the cyan and magenta colours with 300px resolution compared to the same colour codes with 200px and 500px resolution. QR codes in yellow colour have proved to be extremely unreadable in the augmented reality application because their measurement results were quite unstable. Only the QR codes of this colour were not read under all the measuring conditions. Unstable measurement results behaviour led to the conclusion that the use of these colours is extremely unfavourable and should be avoided.
As already mentioned, the examples of unreadable yellow colour codes show that a low contrast between the white background and yellow QR codes adversely affect the readability.

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Correspondence to:

Stefan Đurđević

Faculty of tehnical sciences, University of Novi Sad
Department of Graphic Engineering and Design, Novi Sad, Serbia

djurdjevic@uns.ac.rs

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Upotreba QR kodova kao targeta u aplikacijama proširene stvarnosti

SAŽETAK

Proširena stvarnost predstavlja novu tehnologiju koja putem kamere mobilnog ili stabilnog uređaja realan svet obogaćuje kompjuterski generisanim sadržajem. Kako bi se izvršila veza između realnog i kompjuterski generisanog sveta potrebno je očitati odgovarajuće targete i dovesti u vezu koordinatne sisteme realnog sadržaja zabeleženog kamerom i imaginarnog kompjuterski generisanog sadržaja. U radu je prikazan postupak upotrebe generisanih QR kodova kao targeta za aplikacije proširene stvarnosti. Prikazani su rezultati čitljivosti različitih QR kodova pri različitim uglovima očitavanja. Izvršena je analiza dobijenih rezultata u cilju utvrđivanja uticaja vrste i broja unetih karaktera, rezolucije i boje QR kodova na njihovu čitljivost u aplikacijama proširene stvarnosti.

Ključne riječi: proširena stvarnost, čitljivost, QR kodovi.