NFC Technology and Augmented Reality in Smart Packaging

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Abstract

This paper presents research focused on the application of NFC (eng. Near Field Communication) technology as well as the use of AR (eng. Augmented Reality) in smart packaging. Packaging is smart when it employs an interactive element so consumers can learn more about the product (price, freshness, transport, storage, etc.), engage with a brand (find a brand on social media, web, etc.) and more. The interactivity can come from NFC, AR or with traditional technologies like a barcode, QR code, etc. NFC is a short-range wireless communication technology which transfers data between devices wirelessly without the need for an Internet connection. AR is an image recognition technology which enables adding digital content and interactive experience over a physical touch point of packaging. Connecting more modern technologies gives an opportunity to have information about the product, its quality, characteristics and information about transport and storage at any time. There are various technologies on the market that enable packaging to implement these modern requirements. Putting together NFC technology and smart packaging creates a quick and efficient way to obtain all necessary information about the products contained in the database. The AR in recent years tends to take over the field of application of NFC technology in packaging. In addition to storing information, it also can visualize them in real time and space through smart mobile devices cameras. The goal of the paper is to compare the advantages and disadvantages of these technologies, the way they are implemented in smart packaging technology and the expectations for further development. A comparative overview of the main features of these technologies that are associated with their use in smart packaging. The way these technologies are implemented is shown through a variety of commercial examples. The paper introduces two concepts of application of one and the other technology through which all expectations for further development are presented.

Introduction

Smart packaging is still in its early stages and hasn't yet seen wide roll-out to the world at large. But the technology provides some intriguing benefits that could nudge it into that wider marketing arena.

Packaging is smart when it employs an interactive element so consumers can learn more, engage with a brand, and more. The interactivity can come from NFC, AR, or other digital technologies [1].

Smart Packaging

Smart packaging provides enhanced functionality that can be divided into two submarkets: active packaging, which includes functionality such as moisture control, and intelligent packaging, which incorporates features that indicate product status and other information [2].

Active packaging is packaging, which has an extra function in addition to provide a protective barrier against external influence. It can control, and even react to, phenomena taking place inside the package. Intelligent packaging monitors to give information on the quality and state of the packed product. Smart packaging is defined as a packaging technique containing an external or internal indicator for the active product history and quality [3].

According to a report from Freedonia [4], demand for active and intelligent packaging in the U.S. is forecast to expand 8.0% annually to 3.5 billion dollars in 2017, well above total packaging demand growth. The report identifies food and beverages as the two largest markets for smart packaging in 2012 and projects that pharmaceuticals will be the fastest growing smart packaging market through 2017. In food packaging, some packages can communicate freshness, while others can communicate a product's history or expiration. Regarding the pharmaceutical market, packages in-

tegrating NFC tags to verify authenticity is another example. Other smart packages combine communication with functionality, like self-cooling beer kegs or self-heating soups and coffees [5].
There is a long list of various "smart materials" that enhance smart packages. These include shape memory alloys to control the opening and closing of packages depending on environmental conditions, piezoelectric materials to provide power for lighting and audio features on packaging, smart adhesives that can be used in conjunction with smart labels, and thermochromic inks to show when optimal or dangerous temperatures have been reached [5].

Using AR technology, every packaging can be smart. The AR technology allows the identification of labels on the packaging through the mobile device's camera and provides additional information or starts interactive content from the database based on the given information.

NFC

NFC is short-range wireless communication technology. It can be compared to mobile technologies such as 3G, 4G, WiFi, but NFC is using a different frequency, a different level of power supply, and a communication protocol that performs differently sending and receiving information. NFC tags can communicate at a distance of just a few centimeters. Thanks to this technology, interaction with the environment and information about it are enabled so that NFC tags can be placed on everyday objects such as bus stations, product packaging, posters, magazines, and more. Information about these objects can be shown through mobile devices that can read NFC tags. NFC allows a portable device, most often within a mobile phone, to retrieve data from an NFC tag or other NFC device at a very close distance [6].

The use of NFC increases significantly and evolves, especially in the field of packaging. Initially, it was only used only to track the products, but now it has come to the point that several new concepts have been developed that integrate the physical world with the virtual [7].

For codes printed in the form of printed electronics such as RFID and NFC tags, conventional inks are not used, and the reading principle itself is different. The printing of electronics is done directly on the surface of already existing physical objects or in some cases in/under the surface. Innovative electroconductive inks are used, which can provide the required layout of the printed object, electrical conductivity and durability. Electroconductive, so-called "silver inks", contain transparent silver nanoparticles that achieve an electrical resistance of 200 milliohms (mΩ) per square centimeter in a few minutes of printing. These inks do not require curing or other treatment for most surfaces. It can be printed on surfaces such as polyester, synthetic polymer, coated paper and rigid substrates [8].

Augmented Reality

The term "Augmented Reality" was coined by Caudell and Mizell [9] in 1992, as superimposing computer-generated images onto an environment creating a mixed reality [10]. Unlike virtual reality, which creates an artificial environment, AR uses the existing environment and overlays new information on top of it. That means AR requires less computation resource than Virtual Reality (VR) because it only needs to render the overlaid objects instead of every pixel on the screen.

AR combines real and virtual, it is interactive in real time and registered in 3D [11]. AR combines real and virtual means of information or animations which are displayed on the same screen as the user sees the actual world through, to enhance what the user can see and read out from real-world objects. Interactive in real time means that the user can interact with whatever information is displayed in the AR system.

Comparative Overview of Technologies

To better understand the possibilities of using these technologies in the packaging industry, their significant characteristics will be presented in this section. Table 1 summarises the main characteristics of the technologies related to their application in smart packaging. In terms of the time required to activate the content, the characteristics of both technologies are extremely advantageous. Regarding the range, NFC is a short-range technology and the device for reading the information must be up to 10 cm away from the product [7]. AR technology, depending on the quality of the mobile device camera, can read the information up to several meters away from the product. Regarding usability and selectivity, the technologies are equal and enable easy intuitive and fast use with high data security. Techniques differ in cases of using. Unlike AR technology, NFC can be used for payment, getting access, sharing content etc. AR can be used for advertisement, object recognition etc. Both technologies are easy to set up. From the consumer experience perspective, NFC is characterized by the need for the user to touch the product with the smart device, and it will very easily obtain information through that touch. AR technology is characterized by the putting products into the world of 3D computer-generated content on the mobile device that provides live product information [12].

Table 1 The main characteristics of the NFC and AR technologies

Technology	NFC	AR
Set-up time	<0.1ms	Depends on the mobile device, minimum 0.1s
Range	up to 10 cm	Depends on the mobile device camera, minimum approx. 5 cm, maximum approx 150 cm
Usability	Human centric, easy, intuitive, fast	Human centric, easy, intuitive, fast
Selectivity	High, given, security	High, given, security
Usage	Pay, get access, share, initiate service, easy set up	Advertisement, object recognition, easy set up
Consumer experience	Touch, wave, simply connect	3D, live information

Way of implementation of technologies in smart packaging

NFC implementation

With the simultaneous development and innovation, there is a growing NFC technology application in the packaging industry. Modern packaging ensures the stability of goods in it, requires less material, less waste, and facilitates the handling of goods. By connecting more modern technologies and working methods, we can, at any time, reach information about the product, its quality, its characteristics and the method of transport and storage.

The Diageo compay set up NFC chips for a type of alcoholic drink "Johnnie Walker Blue". Customers who have an NFC-enabled phone can read the information from the NFC on the label and find out if the bottle was in some way misused, i.e. opened. Customers can also receive personalized messages, promotional offers and recipes for cocktails, as shown in Figure 1 [13]. Another advantage is that certain information could be read while the product is still on sale, and other information is displayed when the sensors show that the bottle is open. The innovation was created by the cooperation of the companies "Thinfilm" and "Diageo Technology Ventures", where the patent "OpenSense " technology allows the use of NFC applications in smartphones. This allows the bottle to be tracked through the entire chain of sales, storage and the opening and opening times, where the sensor remains legible even if the factory shutter is broken, thereby providing additional security in the authenticity of the product [14].

Figure 1. An example of the NFC use on a "Johnnie Walker Blue" bottle

The following example is the glass packaging for the French cognac "Remy Martin", which features an NFC chip on the lid. Users can receive information using an NFC enabled smartphone, Figure 2 [13].

Figure 2. An example of the NFC use on a "Remy Martin" bottle

The loaded information is whether the bottle is genuine when the bottle is opened and more details about the drink itself, Figure 3 [13].

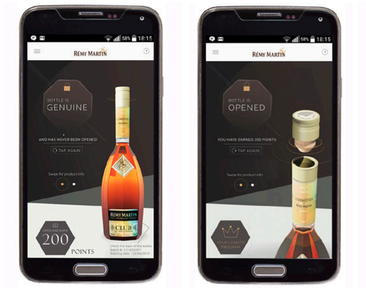

Figure 3. Product information status loaded with NFC technology

The Stora Enso company enabled the integration of NFC technology, in cooperation with NXP Semiconductors, to monitor its products through the entire supply chain, and to provide users with more information about products and their authenticity. Smart packaging is used for product packaging, so Figure 4 shows an example of smart packaging with an applied NFC chip. A bottle of champagne is shown which serves as an ice bucket with light effects to contribute to the visual effects.

The goal is to provide much more information about the product and its safety to customers and to the owners of the brand, detailed analysis of where and when their product is located and about real-time consumer activities [15].

Figure 4. An example of smart packaging with NFC label

One example is the potential for pharmaceutical labels to include NFC technology to help patients better understand the instructions for taking their medication. These labels could also communicate potential side effects and tell the consumer when to see a doctor.

Another example that should make brands take notice: NFC could be used to help cut down on counterfeit goods. A consumer could scan the NFC label on a product with their phone, which would tell them if the product is authentic.

NFC tags could provide other benefits to consumers, too – such as clothing labels that connect users to a Pinterest gallery showing real customers wearing the clothes. Or, the tag could provide customer service functions like contact information for product feedback.

NFC does work with no need for an internet connection. The data is stored inside the NFC tag and is readable with a smartphone app.

From the price point perspective, we see significant reductions in the cost of NFC tags. New developments in flexible electronics are allowing the production of NFC tags at an order-of-magnitude lower price than ever before, as well as radically reducing the value of the assembly processes used to produce tags and inlays. There is a demonstrable route to the much-touted one cents tag, the price point at which NFC is predicted to move from a premium product feature implemented at limited scale or only on high-value products, into the everyday high volume, low-cost Fast-moving consumer goods (FMCG) packaging.

From the technology development perspective, there is an increase in developing NFC readers for consumers' phones. In the year 2017 Apple iOS11 has finally opened up its NFC APIs, allowing third-party apps to read NFC tags using the latest iPhones. It is possible that at the end of the year 2018 over 50% of iPhone users will be able to read NFC tags. Android phones have had this functionality for some time, but although iPhones represent a smaller percentage of the smartphone market, Apple's move is nevertheless a significant development for brands looking to leverage NFC technology and smart packaging for consumer engagement [16].

AR Implementation

From a marketer perspective, AR is an image recognition technology that enables you to add digital content and interactive experience over your physical touch points (Product Package, Marketing collaterals, Printed ads, etc.). The customer unlocks the digital contents through scanning the item with smart device camera (Smartphones, tablets, glasses etc.) using an AR enabled application.

Besides adding objects to a real environment, AR also has the potential to remove them (Figure 5). Graphic overlays might be used to remove or hide parts of the real environment from a user. For example, to remove a packaging (to see the product inside) in the real environment, draw a representation of the real product and space inside of the packaging in front of it, actually removing packaging from the user's sight. Removing full packaging and present it interactively in an AR system will be much harder, but this removal may not need to be photorealistic to be effective [17].

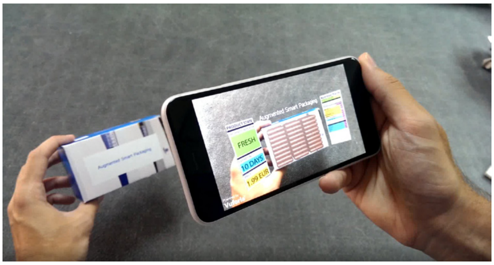

Figure 5. AR Smart Packaging Concept

For instance, a user might look at a food packaging and is provided with information about the food manufacturer and by clicking on this information the user can get the other food product list or the manufacturers website (Figure 6). Registered in 3D means that virtual information is displayed and aligned with the real-world object [17].

Figure 6. Food product and AR app

In 2015 the Belgian brewery Martens Beer came up with a creative promotion for a new flavor of its beer. In partnership with a popular Belgian television show, the company printed AR -enhanced images of the show's characters on the bottles. When scanned with a smartphone (with the brewery's app installed), the character on each bottle would speak to the consumer (Figure 7). The campaign added a novelty touch to the new beer flavor and helped increase consumer engagement with the brand [18].

The novelty aspect of Martens Beer's AR campaign may grow thin if consumers are flooded with smart packaging that focuses on the "cool" factor, rather than function. But the good news is, with a little refocusing smart packaging can provide real-world benefits to consumers and brands alike.

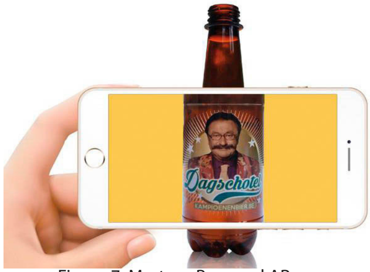

Figure 7. Martens Beer and AR app

While smart packaging hasn't reached mainstream status yet, its potential for consumer engagement and communication makes it an attractive addition to the marketing toolbox. Today there are many examples of the use of AR technology in smart packaging for marketing purposes (Figure 8). There are also great tools for developing such applications for smart packaging like ZapWorks [19].

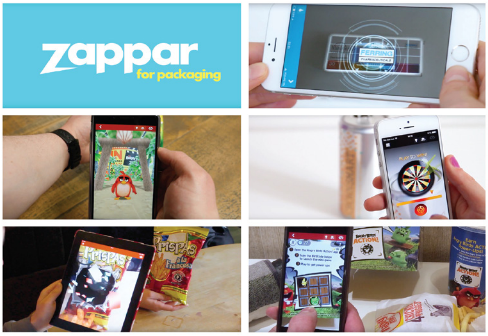

Figure 8. Examples of AR mobile applications for smart packaging

If the AR data is stored on smart device, the AR app does work with no need for an internet connection. But if the database for targets is huge, the data must be stored in the cloud. In that situation, for an AR experience the user does need an internet connection. For GPS features data also can be stored locally, but if the database for GPS coordinates is huge, internet connectivity is a must.

One of the other advantages of AR is its low cost. Besides the costs related to developing the app itself, Augmented Reality doesn't involve any other expenses. No need to redesign or redevelop your packaging. All you need is a packaging design for a target, and the product is ready [20].

AR can be used for premium products or high-value products, as well as into everyday high volume, low-cost Fast-moving consumer goods (FMCG) packaging.

From the technology development perspective, there is an increase in developing AR-enabled phones. There are many AR applications in use or under development today, however – the concept will only take off universally when the user experience designers think about how they can integrate AR with daily life to improve productivity, efficiency or quality of experiences. In the year 2017 in iOS11 Apple has finally introduced ARKit, a tool for developing AR native iOS apps in Swift, the programing language for Apple software products. Also, the new Apple smartphones lineup presented in 2017 Apple event had dual cameras which can enhance AR experience. Earlier models of iPhones and Android phones have had this functionality for some time, but now AR will be more and more reliable technology because of better cameras and processors of smart devices [21].

Concepts of technology application and expectations for furture developmentC

NFC and AR concepts of smart packaging that are developed at the Department of Graphic Engineering and Design are shown below.

NFC SMART PACKAGING APPLICATION CONCEPT

To develop a website with product information when reading the NFC element on a smart packaging an HTML (Hypertext Markup Language) was used to create the basic page structure.

By defining the elements on the webpage with HTML, their styling with CSS, the starting pages for three different products were made, showing that the packaging of the product is genuine and unopened, Figure 9. The first HTML page, which would be opened by reading from the NFC tag, contains several basic information and a product photo.

<img src="images/or.png" id="cream" alt=" hand cream" >
<h1> Hand cream </h1>
*<p class="tekst"> The product packaging is original and unopened.
*
*° Expiration date: 12th September 2020
*
*° Serial number: 44441234
 </p>*

In the given case, two selectors can be seen to serve further CSS stylings, such as a class selector and ID selector. The element <h> serves to mark the title. The <p> element serves to mark the paragraph. The <span> element is used to stylize short texts that differ from the rest of the text. The <img> element is used to refer to a raster image, that the web browser will show.

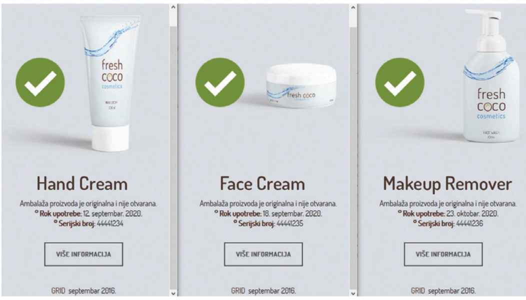

Figure 9: Web pages after reading unopened packaging products

For this work, two applications have been used for programming NFC. "NFC Tools" which proved to be the fastest, with the possibilities needed for this work (Figure 10) [22]. Using this application, it is possible to program the desired options. The other application required to perform the programmed options is "NFC Tasks" [23].

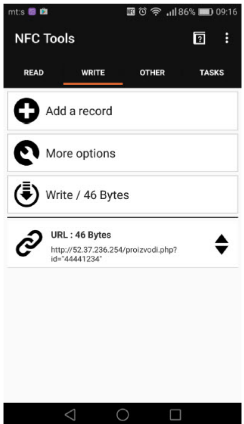

Figure 10: Appearance of the "NFC Tools" application during the URL adding

fter launching the application, the write>add and record>URL/URI options are selected and the address is entered in the marked field: http://52.37.236.254/proizvodi.ph p?id="44441234". For the web server, the HTTP server "Apache", version 2.4, was used (Figure 11). After that, it is only necessary to bring the NFC tag close to the device with is entered data and automatically copy it to the memory of the label. Creating a database of products can be done in many ways. In this case, connecting to the database server was done using the MySQL Workbench tool. When the NFC tag accesses the website, through PHP, one SELECT query is executed in a database that obtains the necessary data based on the entered ID or the serial number of the product.

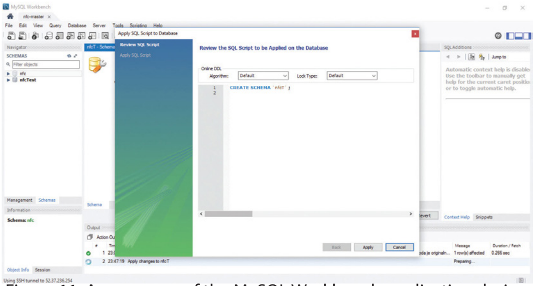

Figure 11: Appearance of the MySQL Workbench application during the table adding

Certain website data for displaying product information when reading the NFC element is located in the database, so it is necessary to create a link between static pages written in HTML and the database itself. In this case, the PHP scripting language was used, which can connect to the database and display the data. Below is a section of the PHP code to link the database with the HTML page.

```
<?php
// Creating a connection
$conn = new mysqli($servername, $username, $password, $dbname);
// Checking the connection
if ($conn->connect_error) {
die(“Connection failed: “ . $conn->connect_error); }
?>
```

Part of the PHP code of the page “products.php” through which the data from the database is obtained:

```
require_once(‘db_connect.php’);
$id = $_GET[‘id’];
if (isset($id)) {
```

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if (isset($id)) {

AR Smart Packaging application concept

The following applications were used for the development of the AR smart packaging application: Unity 2018.1.0f2 which has an integrated platform for AR called Vuforia. The Vuforia developer website was used for AR target creation, Xcode 9.4.1 was used to build an application for an iOS device, as well as Adobe Illustrator CC, Adobe Photoshop CC and Sketch for creating an application design interface.

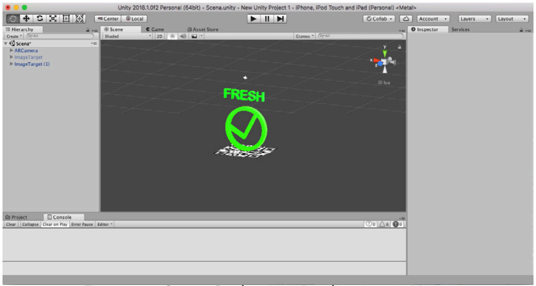

Figure 12. Smart Packaging Application in Unity

The basis of this application is the special QR code consisting of fields printed with conventional inks and fields printed with irreversible thermochromic inks that disappear if they reach the higher temperature in the ambient than the activation temperature (for the used type of ink 30oC). Developing code for this type of smart packaging labels was shown in a previous research project [24].

Smart labels are applied to existing packaging, where the first target is the segment of packaging design side to the applied label, second is the non-activated label code design, and the third is the label code in the activated form. In this way, the device recognizes the product and the status of the label code, and by linking these two information together gives the freshness state of the product. For example, if the frost product is concerned, activating the thermochromic ink will signal that the product was thawed during storage, and because of that, it is not fresh anymore.
Parts of the user interface design were created in Adobe Illustrator, and integrated into UI the design software Sketch (Figure 14). Finally, the user interface design from Sketch is used in Xcode.
It can be seen that based on the GPS location, additional information about the identified product is also loaded on the interface, such as the price, the declaration, the store, the

expiration date (Figure 15).

In order to build the application on a mobile device, Xcode 9.4 and the programing language Swift were used (Figure 13).

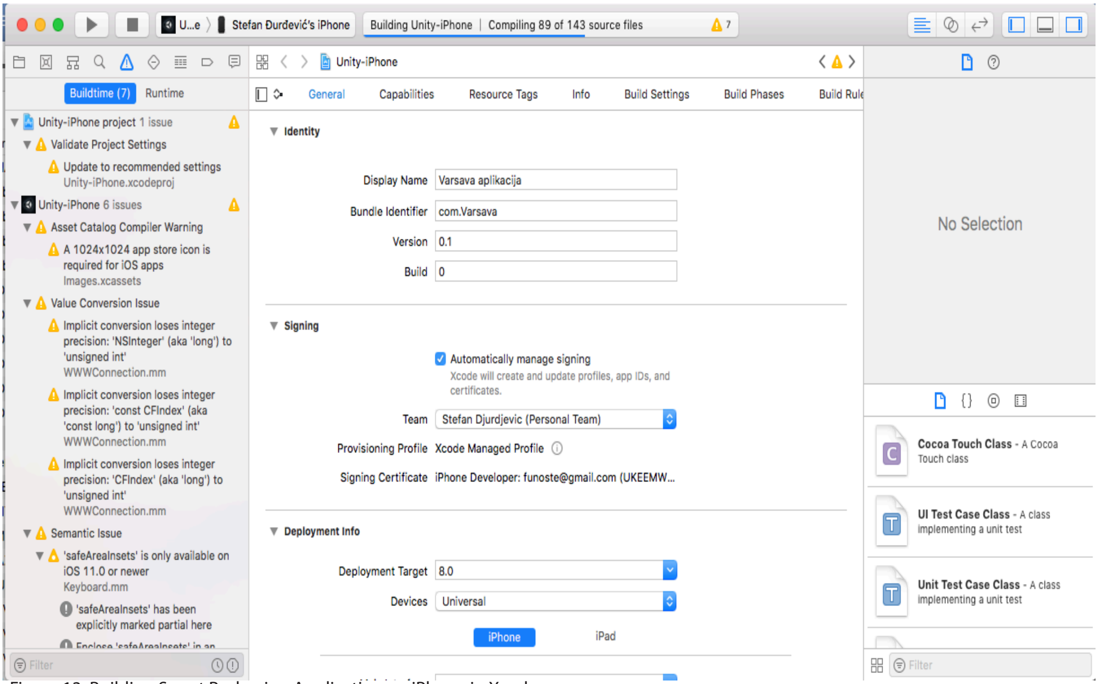

Figure 13. Building Smart Packaging Application on iPhone in Xcode

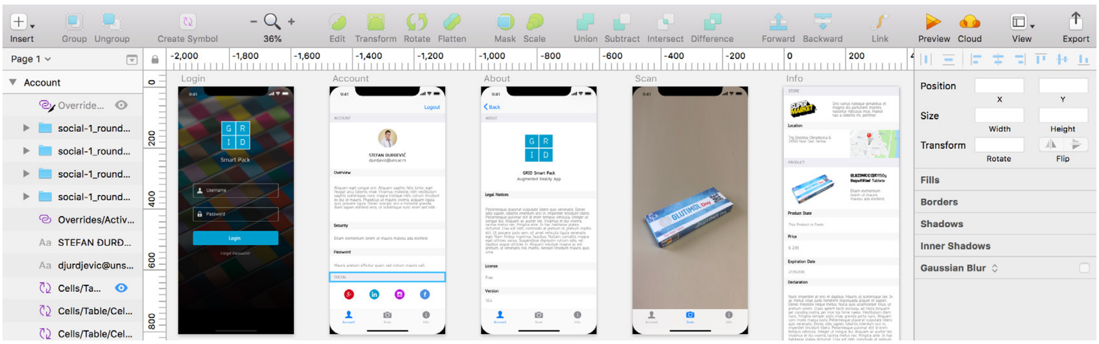

Figure 14. Smart Packaging Application UI development

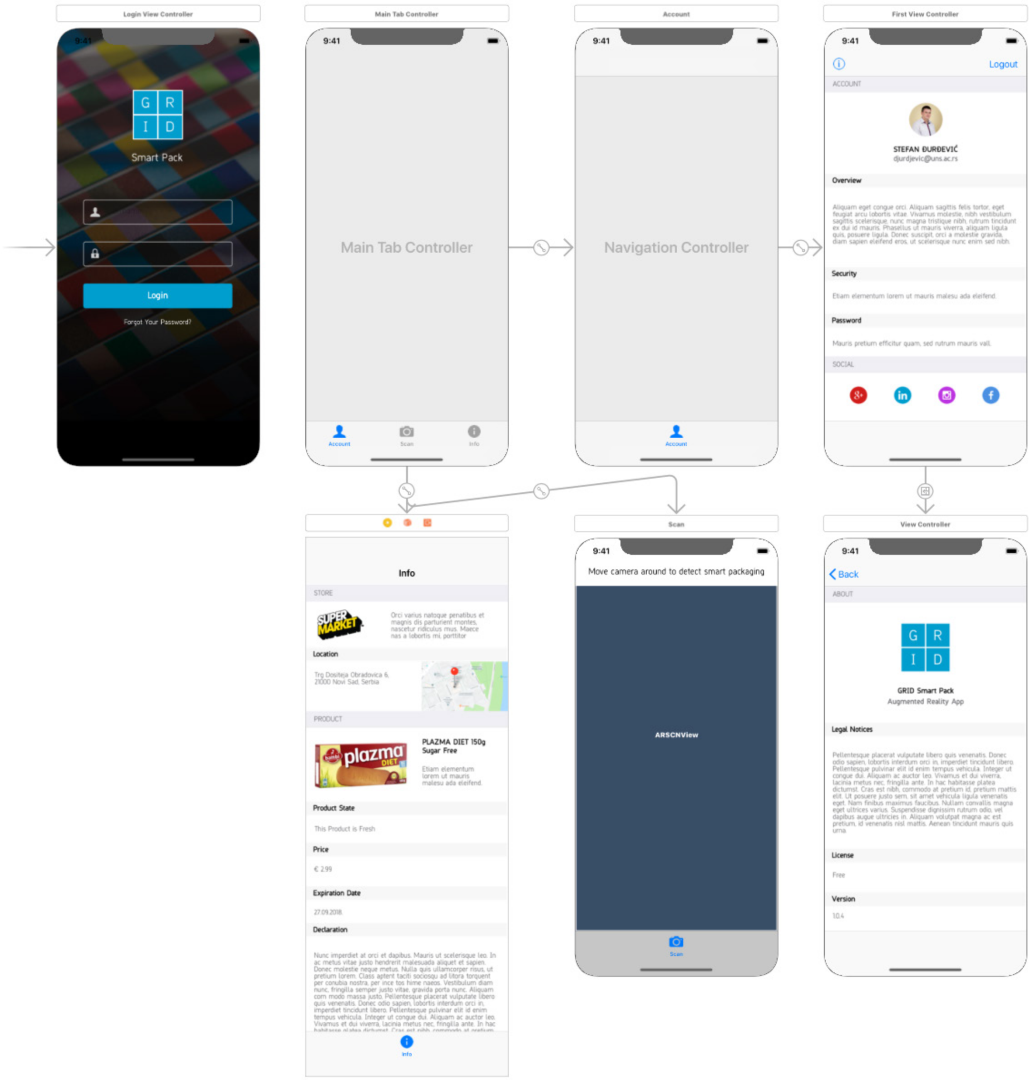

Figure 15. Smart Packaging Application UI development

Figure 15 shows View Controllers in Xcode with the application interface screens. The "Scan" tab allows you to launch an AR camera that recognizes the product and its freshness and prints data within the "Info" tab. Below is the code that is associated with the View Controller "Scan" tab (Figure 16) and "Scan" tab in use while the application is running on smartphone (Figure 17).

```swift
//
//  SecondViewController.swift
//  GRID AR
//
//  Created by Stefan Đurđević on 9/13/18.
//  Copyright © 2018 GRID. All rights reserved.
//

import Foundation
import UIKit
import ARKit

class SecondViewController: UIViewController {


    @IBOutlet weak var sceneView: ARSCNView!
    @IBOutlet weak var label: UILabel!



    let fadeDuration: TimeInterval = 0.3
    let rotateDuration: TimeInterval = 10
    let waitDuration: TimeInterval = 0.5

    lazy var fadeAndSpinAction: SCNAction = {
        return .sequence([
            .fadeIn(duration: fadeDuration),
            .rotateBy(x: 0, y: CGFloat.pi * 360 / 60, z: 0, duration: rotateDuration),
            .wait(duration: waitDuration),
            .fadeOut(duration: fadeDuration)
            ])
    }()

    lazy var fadeAction: SCNAction = {
        return .sequence([
            .fadeOpacity(by: 0.8, duration: fadeDuration),
            .wait(duration: waitDuration),
            .fadeOut(duration: fadeDuration)
            ])
    }()

    lazy var treeNode: SCNNode = {
        guard let scene = SCNScene(named: "fresh.scn"),
            let node = scene.rootNode.childNode(withName: "fresh", recursively: false)
else { return SCNNode() }
        let scaleFactor = 0.010
        node.scale = SCNVector3(scaleFactor, scaleFactor, scaleFactor)
        node.eulerAngles.x = 0
        node.runAction(SCNAction.rotateBy(x: 0, y: 0, z: 0, duration: 0.0))

        return node
    }()

    lazy var bookNode: SCNNode = {
        guard let scene = SCNScene(named: "do not use.scn"),
            let node = scene.rootNode.childNode(withName: "do not use", recursively:
false) else { return SCNNode() }
        let scaleFactor  = 0.1
        node.scale = SCNVector3(scaleFactor, scaleFactor, scaleFactor)
        return node
    }()
    lazy var mountainNode: SCNNode = {
        guard let scene = SCNScene(named: "check due date.scn"),
            let node = scene.rootNode.childNode(withName: "check due date", recursively:
false) else { return SCNNode() }
        let scaleFactor  = 0.25
        node.scale = SCNVector3(scaleFactor, scaleFactor, scaleFactor)
        node.eulerAngles.x += -.pi / 2
        return node
    }()

    override func viewDidLoad() {
        super.viewDidLoad()
        sceneView.delegate = self
        configureLighting()
    }
    func configureLighting() {
        sceneView.autoenablesDefaultLighting = true
        sceneView.automaticallyUpdatesLighting = true
    }

    override func viewWillAppear(_ animated: Bool) {
        super.viewWillAppear(animated)

        resetTrackingConfiguration()
    }
    override func viewWillDisappear(_ animated: Bool) {
        super.viewWillDisappear(animated)
        sceneView.session.pause()
    }
    @IBAction func resetButtonDidTouch(_ sender: UIBarButtonItem) {
        resetTrackingConfiguration()
    }
    func resetTrackingConfiguration() {
        guard let referenceImages = ARReferenceImage.referenceImages(inGroupNamed: "AR
Resources", bundle: nil) else { return }
        let configuration = ARWorldTrackingConfiguration()
        configuration.detectionImages = referenceImages
        let options: ARSession.RunOptions = [.resetTracking, .removeExistingAnchors]
        sceneView.session.run(configuration, options: options)
        label.text = "Move camera around to detect smart packaging"
    }
}
extension SecondViewController: ARSCNViewDelegate {

    func renderer(_ renderer: SCNSceneRenderer, didAdd node: SCNNode, for anchor:
ARAnchor) {
        DispatchQueue.main.async {
            guard let imageAnchor = anchor as? ARImageAnchor,
                let imageName = imageAnchor.referenceImage.name else { return }
            let overlayNode = self.getNode(withImageName: imageName)
            overlayNode.opacity = 0
            overlayNode.position.y = 0.2
            overlayNode.runAction(self.fadeAndSpinAction)
            node.addChildNode(overlayNode)

            self.label.text = "Smart packaging detected: \"\(imageName)\""
        }
    }
    func getPlaneNode(withReferenceImage image: ARReferenceImage) -> SCNNode {
        let plane = SCNPlane(width: image.physicalSize.width,
                             height: image.physicalSize.height)
        let node = SCNNode(geometry: plane)
        return node
    }
    func getNode(withImageName name: String) -> SCNNode {
        var node = SCNNode()
        switch name {
        case "Milka Chocolate":
            node = bookNode
        case "Glutimol Day":
            node = mountainNode
        case "Plazma Diet":
            node = treeNode
        default:
            break
        }
        return node
    }

}
```

Figure 16. AR View Controller Swift language code in Xcode

Figure 17. AR Smart Packaging App Demo

Conclusion

One of the main disadvantages of NFC technology, which relates to the packaging industry constraints, is a limited number of devices that support NFC, unlike AR technology that can read all kinds of printed codes with image recognition technology with any mobile device that has a built-in camera. Also, while codes with legible AR technology can be printed with any printing technique using different types of inks and surfaces, NFC tags require special printing technique and inks. The lack of NFC packaging in the packaging industry can also refer to the consumer's understanding of the additional packaging costs, i.e. the product itself, and in addition to the possibility of mistrust or confusion regarding NFC technology. For example, if the packaging lasts both the printed expiration date and a visual indicator of the product freshness, the buyer can come to the confusion were to pay attention. When it comes to AR technology, the customer has no sense of additional packaging costs because instead of a special technology, image recognition technology is used, and it is more similar to barcodes readers. Regarding the environment and consumer attitudes towards packaging, the opinions are somewhat confusing and contradictory. There is a growing concern about the amount of waste generated by the smart packaging, but at the same time consumers desire for new, attractive packaging solutions is growing. Also, future consumers, more aware of their environment, who follow a particular lifestyle, can react negatively to increased waste and lack of recycling capabilities for one-off smart packaging products.

The NFC concept shows that it's very simple to create an NFC application for reading content from smart packaging. As far as the expectations related to the development of NFC technology in smart packaging are concerned, we can hope for more information that can be placed on the tag, better encryption, i.e. data protection, while there are no expectations for the significant change in interactivity and attractiveness in use for the packaging industry.

The AR concept of the smart packaging shows that it is possible to create an application for reading content and checking the product freshness in smart packaging using smart labels. Current technological advances ensure the implementation of such a control system. In the future, we expect the fall in prices of smart inks for printing smart labels and greater development of AR. Advances in powerful CPU, camera, accelerometer, GPS, and solid-state compass are present in all mobile phones today, making them the best hand-held platform for this AR system. However, their small display size is less than ideal for 3D user interfaces, but it is expected that in the future this system will be able to adapt and head mounted displays (HMD) and spatial displays.

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References

1. Annon: "Is Smart Packaging the Wave of the Future? ", URL http://united-mail.com/blog/2017/smart-packaging-wave-future/, (accessed March 10, 2018)

2. Annon: "Packaging Digest, Smart Packaging ", http://www.packagingdigest.com/smart-packaging, (accessed April 7, 2018)

3. Bente, F., Hellstrom, B., Henrysdotter, G., Hjulmand, M., Nilsson, J., Rudinger, L., Sipilainen, T., Solli, E., Svensson, K., Thorkelsson, A., Tuomaala, V.: "Active and intelligent food packaging: a Nordic report on the legislative aspects", Copenhagen, 2000

4. Rick, L.: "Smart packaging forecast to grow 8 percent annually", http://www.packagingdigest.com/smart-packaging/smart-packaging-forecast-grow-8-percent-annually, (accessed March 12, 2018)

5. Chris, Mc L.: "Hot or Not? Thermochromic inks make smart packages smarter by communicating temperature. ", http://www.packageprinting.com/article/smart-packaging-thermochromic-inks-53226/all/, (accessed April 3, 2018)

6. Petković, A.: "Šta je NFC i čemu služi? Softver tehnologija ",http://mo-bilnimarketing.me/, (accessed June 4, 2018)

7. Vasquez-Briseno, M., Hirata, F., Sanchez-Lopez, J., Jimenez-Garcia, E., Navarro-Cota, C., Nieto-Hipolito, J.I.: "Using RFID/NFC and QR-Code in Mobile Phones to Link the Physical and the Digital World. ", Interactive Multimedia, Dr Ioannis Deliyannis (Ed.), ISBN: 978-953-51-0224- 3, 2012

8. Annon: "Methode Electronics,inc.", URL http://www.methode.com/sensors-and-switches/conductive-and-resistive-inks.html (accessed May 16, 2018)

9. Caudell, T. and Mizell, D.: "Augmented Reality: An Application of Heads-Up Display Technology to Manual Manufacturing Process". Twenty-Fifth Hawaii International Conference on System Sciences, vol. 2, pp. 659 – 669 (1992)

10. Furht, B.: "Handbook of Augmented Reality", New York, 2011.

11. Azuma, R. T.: "A Survey of Augmented Reality", Teleoperators and Virtual Environments 6, pp. 355-385, 1997.

12. Tholsgard, G.: "3D rendering and interaction in an augmented reality mobile system", Department of Information Technology, 2014

13. Simpson, J.: "NFC technology in packaging: does it have a future?" https://econsultancy.com/blog/66690-nfc-technology-in-packaging-does-it-have-a-future/, (accessed May 17, 2018)

14. Wasserman, T.:" NFC packaging updates the lowly QR code, but will consumers care?", URL https://www.campaignlive.com/article/nfc-packaging-updates-lowly-qr-code-will-consumers-care/1380081 ,(accessed June 14, 2018)

15. Clark, M.: "NFC technology: Stora Enso and NXP to make intelligent packaging with NFC", https://www.nfcworld.com/2015/05/29/335586/stora-enso-and-nxp-to-make-intelligent-packaging-with-nfc/ , (accessed July 11, 2018)

16. Annon: "Labels and Labeling ", http://www.labelsandlabeling.com/opinion/latest/what-does-2018-hold-nfc-and-rfid-enabled-smart-packaging, (accessed September 15, 2018.).

17. Đurđević, S., Novaković, D., Zeljković, Ž., Avramović, D.: "Using augmented reality technology for controlling state of smart packaging products" International Symposium on Graphic Engineering and Design, pp. 427-437, GRID 2016 conference, conference proceedings, http://www.grid.uns.ac.rs/symposium/download/grid16.zip

18. Adriaensen, P.: "Belgian brewery prints on PET bottles and adds augmented reality to support popular TV show ", https://www.agfagraphics.com/global/en/articles/news/20150814_martens-beer-bottles.html, (accessed June 10, 2018)

19. Annon: "Augmented Reality for Packaging " http://www.zappar.com/solutions/packaging/ , (accessed May 19, 2018)

20. Annon: "Swedbrand Group ", http://www.swedbrand-group.com/blog/augmented-reality-revolutionizing-packaging-industry, (accessed September 15, 2018)

21. Annon: "Interaction Design", https://www.interaction-design.org/literature/article/augmented-reality-the-past-the-present-and-the-future, (accessed September 15, 2018)

22. Annon: "NFC Tools", https://nfc-forum.org/nfc-products/nfc-tools/, (accessed March 20, 2018)

23. Annon: "NFC Tasks", https://play.google.com/store/apps/details?id=com.wakdev.nfctasks&hl=en, (accessed March 20, 2018)

24. Đurđević, S., Novaković, D., Zeljković, Ž., Kašiković, N.: "Thermochromic inks and augmented reality as part of novel smart packaging solutions", 2nd International Printing Technologies Symposium pp. 153-159, Istanbul, Turkey, 2017

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