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Improving Food Consciousness - Opportunities of Smartphone Apps to Access Food Information

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ABSTRACT

Factors of food choice have an increasingly important role in the life of consumers. Information and codes on food packages are the most widespread standard to support the decision among the many types of food products. There should be mandatory information on packages that are governed by regulations. However, there can be other labels too that help consumers in choosing food products that match personal needs and concepts, including not only nutritional information but ethical factors as well. In our literature review, we overview the current trend of food labels and the results of research on the role of food information among consumers. The focus of this study is on smartphone applications and Augmented Reality (AR) as an advanced technology to display personalized food information. In this paper, we surveyed and analyzed the attitude of young food consumers due to their personal needs, the extent of attention to package information, and the most important factors when purchasing goods. We also surveyed the interest in smartphone applications that may support the decision. Our results suggest that there is a willingness to use an interactive application to gain personalized food information immediately. The majority of respondents would use an application that provides complex information service. Within the framework of the studied criteria for implementing a smartphone application using a database behind, we outline a theoretical infrastructural model too, for collecting and handling the necessary data. Our work has led us to conclude that there are opportunities of using smartphone applications to access food information and we suggest some solutions that may increase the Quality of Experience, such as AR.

1. Introduction

There is a growing demand from consumers for nutritional qualities and detailed information about food products. Several empirical research studies applying consumer questionnaires showed that most respondents are willing to read food labels to check whether a product meets certain criteria (Bandara et al., 2016). However, consumer surveys also showed that food labels do not provide enough information to make choices and are difficult to understand (Madilo et al., 2020). Thus, food purchases are typically still influenced by routines and habits that represent a barrier to conscious decision (Flaherty et al., 2020). Food choice and understanding food labels are influenced by several factors. Information on package labels, in accordance with European Union regulations, helps customers (e.g. logos, food components, nutritional values, allergenic substances, etc.), however, it takes time reading and interpreting them (font size, language, technical knowledge of the consumers, etc.).

We are of the opinion that digitalized display opportunities can greatly assist in satisfying the need for information. The unique identifier on the packaging of the products (this can be RFID, QR code,

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barcode) can be used to develop an application that is able to provide information in a comfortable and accessible way (Cornelisse-Vermaat et al., 2008). Coughlin et al. (2016) carried out a literature review and found that smartphone apps are likely to be a useful and low-cost intervention for improving diet and nutrition and addressing obesity in the general population.

Regarding the architecture and development such an application that provides connection between consumers and food information, it has to take into account the many interactions and great amount of data exchanging through the application.

It is essential to co-construct mobile apps with consumers by understanding the food practices, identifying relevant sustainability issues in different food practices, and exploring how mobile apps can be best of use in changing their current food practices towards more sustainable food practices (Mu, Spaargaren & Lansink, 2019). Furthermore, to improve nutrition-information app effectiveness, it is suggested that consumer behaviour scientists, marketing researchers, nutritionists, and app developers cooperate in the app’s design (Samoggia & Riedel, 2019). To set up a database behind the application is difficult with even an indirect stakeholder (e.g. software developer) since the collection of data about food products would be huge. However, consumers can help in building database. Information sharing is a popular strategy when users can obtain the benefits of the service when they contribute to it (Kuttschreuter & Hilversa 2019). There are consumer-assisted online food databases. Some popular diet-tracking websites store data on more than 3 million foods collected by consumers, however, the reliability of the data is questionable, but hopefully by merging the technologies currently used to develop and maintain online food databases lead to a comprehensive, reliable, and up-to-date database (Gilhooly et al., 2015). In the paper of Dunford et al. (2014) the FoodSwitch mobile app and its usage features were presented and through a crowdsourcing function integrated within the app, nutritional information for more than 30,000 products has been obtained from users.

By analysing current social trends, technological trends, consumer trends, and problems related to the agri-food sector, the product designers can propose new products that can take advantages of current technologies (Miranda et al., 2019). Advanced-level technologies such as AR (Augmented Reality) and VR (Virtual Reality) can have a positive effect on readiness to use through consumer experience (Crofton et al., 2019). VR has a prominent role among current business opportunities as it could be a tool to complement consumer experience during shopping (Farah, Ramadan & Harb, 2019). Applying the AR concept on a mobile platform to push forward an innovative way to present products digitally, delivering new user experiences to the e-marketing world (Wiwatwattanaa et al., 2013). Recent advances in AR have attracted much attention in nutrition and healthcare education too (Chanlin & Chan, 2018).

Gilliland et al. (2015) analysed the effectiveness of using a smartphone app (SmartAPPetite) to promote healthy dietary behaviours and local food consumption and it was found that the app was effective at creating a sense of improved awareness and consumption of healthy foods, as well as drawing people to local food vendors with greater frequency. In the study of Megan et al. (2017) an AR food serving aid (ServAR) was evaluated and the results emphasized the potential this application as a practical tool to guide the serving of food. An Android-based application (FoodGo) that is able to scan barcode and use cloud database showed effectiveness in helping consumers make a healthier food choice (Abao, Vilela-Malabanan & Galido, 2018). Palacios et al. (2018) evaluated the impact of using MyNutriCart application and concluded that using such tools could reduce costs and resources for improving household food purchase and dietary quality. An Italian study presented an application that can read product labels and then evaluate the quality of ingredients and nutrient values based on the user’s personal data (e.g., age or physical activity level) and suggests healthier food alternatives. The results suggest that this application has the potential to change existing patterns of behavior and encourage a more conscious approach to buy food (Samoggia & Riedel, 2020). Zulkifli et al. (2020) tested an AR application (Nutrilabelapps©) and their findings showed that there are significant relationships between knowledge, attitude, feasibility and acceptability on AR nutrition menu labelling application. Since food products come from a wide range of countries and sometimes labels are not accessible in the necessary language, Jagtap et al. (2021) presented their application (IAR) that can provide automated translations of the product labels.

Improvements in mobile app design are required to maximise their potential effectiveness to support healthier food choice, (Flaherty et al., 2017). There is a significant opportunity for improvement in terms of personalized nutrition, which could include individualized feedback, diet plans, or nutrition education (Zenun Franco et al., 2016). Based on widespread literature research, different features used in studies were collected and classified in the study of Tonkin, Brimblecombe & Wycherely (2017) and the potential of game elements in nutrition apps is included.

Developing smartphone apps involves expenses, however, according to a study analyzing 500 healthcare applications, most of them (92.8%) were available free of charge (Krishnan & Selvam (2019). But in the case of free applications, there are also opportunities to make users spending money and this is the Free-to-Play financial model (Flunger, Mladenow & Strauss, 2017). For instance, the above mentioned game-style apps with a storyline or character, or quiz-style games for discounts or rewards. Regarding the development of an application supporting food choice, Hartwell et al. (2019) presented a four-stage development method (applied by the FoodSMART project) where the first step was the identification of consumer criteria for information quality and the second step was the development of a flexible, customizable and accessible interface. Thus we also started our research with a brief consumer survey that is presented in the first part of our results and then we provide a description about a potential approach to begin such application development. The aim of our research is to make a preliminary study on some attitudes about the importance of food information for consumers and to design a concept for an application that can help in decision making when purchasing goods.

2. Methodology

We performed a bibliometric analysis as this method is suitable to determine the research direction. We used the international literature database of Web of Science (WoS). We used the most important keywords that are relevant to the topic. The keywords applied were created as logical sets in order to establish a relevant data set that includes topics about food, technology (information technology, mobile application) and related research directions that predefined based on preliminary literature review (consciousness, health, nutrition, information, label, choice, consumer behavior, decision). Multiple data cleansing was performed on the data set in order to gain a more precise result, with a reduction of the data noise (merging keywords, handling synonyms, deleting records from less relevant research fields). The final result was a network analysis which is based on a common occurrence matrix with the most relevant keywords (having the most links), highlighting the important research topics. The outcome of the analysis was the frequency of the keywords and the distance between them. We applied visualization software to the result using force-directed graph.

Based on the literature review, we investigated that food information, which serves as the most important factor in the decision of the consumers aged 18-25, furthermore their willingness to use to smartphone applications supporting food choice. For the selection of the age bracket for our survey we used previous studies in a similar topic which found that most university students surveyed on healthy diet are interested in not only calorie counting but the content of nutrients, ingredients and processing technology (Fernandes et al., 2015). Furthermore, the use of smartphones, as well as the use of smartphone applications is the highest in this age group (Eurostat, 2020). We examined the age group's views on product ingredients and respondent's interest in services available through mobile apps that act as a bridge between consumers and product information, supporting healthy and informed food choices. The analysis of the target group was conducted in the framework of a survey and the focus was on to find out attitudes about conscious and health-oriented choice of food products and how the user experience could be increased by a smartphone application. The applied questionnaire was our own compilation based on the literature review and it was accessible online. There were 22 questions divided into 4 groups: demographics; nutrient intake; food choice; interest of a smartphone application to help food choices.

In this study, we evaluated some questions (Table 1) to determine the main decision factors during purchasing food products.

Table 1. The main characteristics of the respondents

Research question	Answer options
Do you purchase food products for yourself?	I do my own shopping always I do my own shopping most of the time I do shopping very rarely I eat what my family buy
Do you have any special diet requirement?	Food sensitivity Diet requirements Diseases
What is involved in comparing similar products?	Price Quality Brand Quantity Food components Packaging
What is involved in your 3 most important decision factors when purchasing food products?	Price Quantity Food components Allergens Trademarks/logos
How important to you NOT choosing food products that may contain harmful ingredient(s) to your health or the environment.	1-not important ----- 4-very important
How often do you overview the food components on the package of the product?	1-never ----- 4-always
Are you interested in a smartphone application that may support the following functions?	Compare similar product alternatives Display certain food components Display place of origin Complex version of all the above

Students studying at two faculties of the University of Debrecen took part in the voluntary and anonymous data collection and in total 376 replies were received using random sampling in the 4th quarter of 2019. The basic characteristics of the respondents can be seen in Table 2.

Table 2. The main characteristics of the respondents

Population: (number of full-time students)	4 454
	at Faculty of Economics and Business: 3 285
	at Faculty of Agricultural and Food Sciences and Environmental Managament: 1 169
Number and rate of respondents:	376 (8.4%)
of which male:	44%
of which female:	66%
Average age:	20 (age bracket: 18-25)

The questionnaire was pre-tested with the participation of 20 students and the final form of the questions and answer options were prepared based on the suggestions. In the absence of data on gender and age for the population, the representativeness of the sample for the two faculties cannot be judged in terms of grouping criteria, and the results cannot be generalized for either the students of the University of Debrecen or the university students in general.

Descriptive Statistics and Ordinal Logistic Regression (where 4-point Likert scale was available) were used to analyse our data and the software package used was R statistics and Microsoft Excel. Ordinal Logistic Regression was used to determine the probability for Likert values. Dependent variables were indicators assessed on a Likert scale and independent variables were the grouping factors (purchasers with or without any special diet requirement). The model calculated the significance of coefficients and intercepts and since the p-value was <0.05 for all variables, they are statistically significant at a 95% confidence interval.

3. Results

Our results are presented in three subsections according to our research directions. First, we present a network map used the analysis of keywords collected based on the literature review; this established the direction of the research. Then, we present the results of the questionnaire that are relevant to the present research topic, namely, the importance of some product information and the choice and use of mobile applications. Finally, we describe a possible system architecture with some technology suggestions related to implementation.

3.1 Analysis of keywords

The results of the bibliometric analysis were used to define our research area and to determine the aspects of our questionnaire and to formulate the hypotheses. This method allows us to determine connected research fields and to quantify these relationships. The result of the analysis is a network map (Figure 1.), visualized by external software that highlights the most important keywords and connections and distances among them and their importance (the size of the circles meaning the frequency of the keywords), furthermore the colors represent different research area clusters.

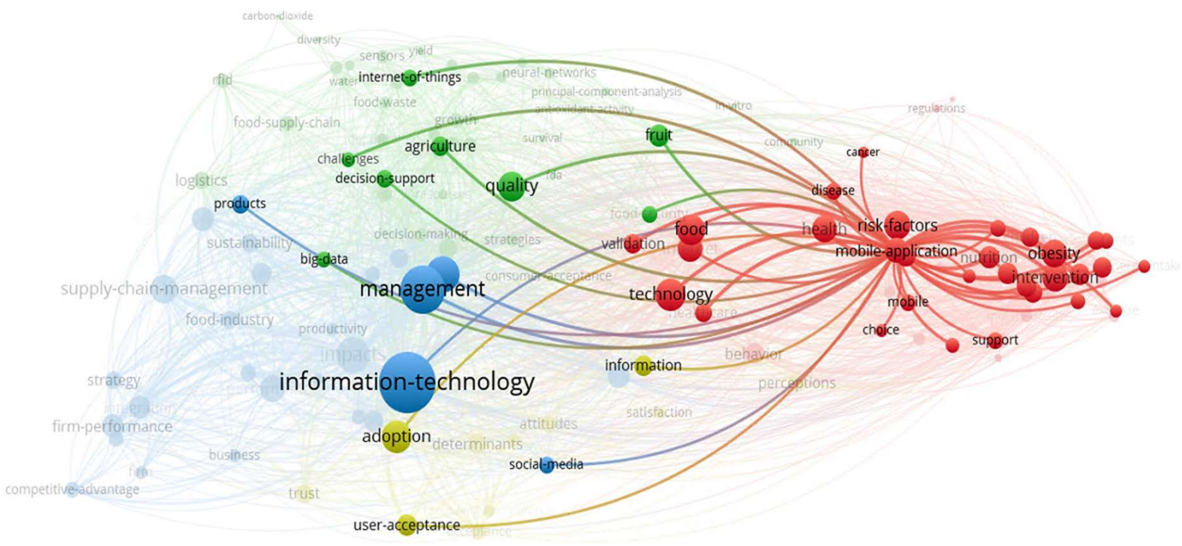

Figure 1. Network map of keyword analysis – Links from mobile application within the studied topic

The network analysis established our research. The most important related research domains from the keyword of mobile application are shown in the above figure. In the current paper, we focus on the research areas in the lower direction from the central keyword (mobile, choice, support, information).

3.2 Analysis of the user questionnaire

Our first analysis was the share of respondents regarding those questions where the food ingredients aspect was in focus. We analysed those respondents who are frequent purchasers (do their own shopping always or most of the time); n=226, 60% of total respondents. We also show the share of those purchasers who checked any special diet requirement; n=84, 37.2% from purchasers. Figure 2 shows their replies about food ingredients.

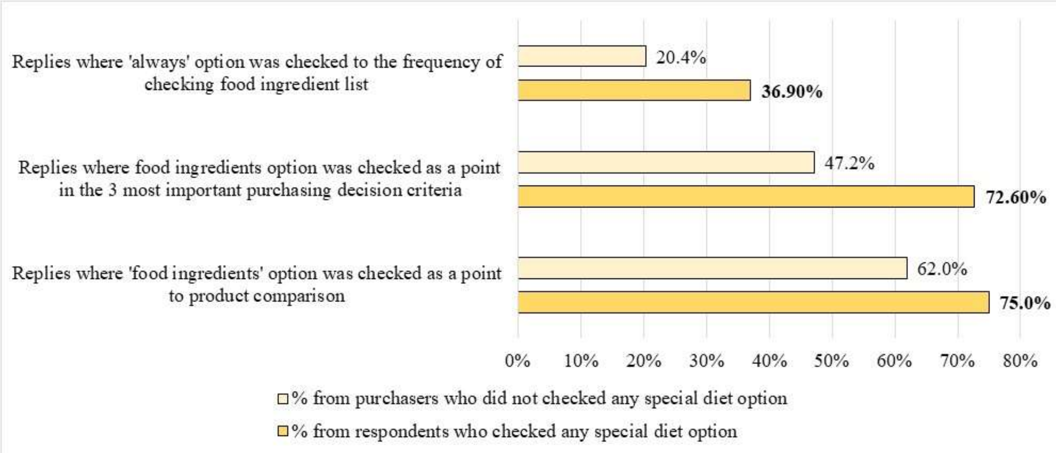

Figure 2. Percentages of replies from questions where the food ingredients aspect was in focus

Based on answer proportions, having a special diet need is an important factor in food choice. Respondents having any special diet need to be considered important not to choose a product that may contain ingredients harmful to health or environment, however, the proportion of respondents who check the food component list always, is lower than expected. To compare product alternatives, respondents indicated food ingredients as one of the most important factors.

In the following section, we analysed the whole respondent population (n=376) by the need for any special diet, as regardless they purchase or not. Those ones who have any special requirement for the food products could be the target group for a possible smartphone application supporting food choice. Ordinal logistic regression method was applied for the following analysis. The impact of the need for any special diet for the evaluation of two research questions (as independent variables) was analysed.

Table 3. Result of the ordinal logistic regression

	Value	Std. Error	t-value	p-value
How important to you NOT choosing food products that may contain harmful ingredient(s) to your health or the environment.	0.678	0.2044	3.318	0.001
How often do you overview the food components on the package of the product?	0.836	0.2015	4.149	0.000

Based on the results, we determined that special dietary needs have an impact on the evaluation of the two research questions. For the first question, the increase per unit in special dietary need caused a 0.678-unit increase in log-odds related to the positive evaluation of the research question ($p = 0.001$). For the second question, it caused an increase of 0.836-unit in the log-odds ($p \leq 0.001$). Recalculating values, it can be stated that a higher rating of the special diet per unit represents a 1.97-times increase in the higher category of the opinion expressing the evaluation of the first question, while for the second question this value is a 2.31-times increase. The values expressed in probability are shown in Figure 3.

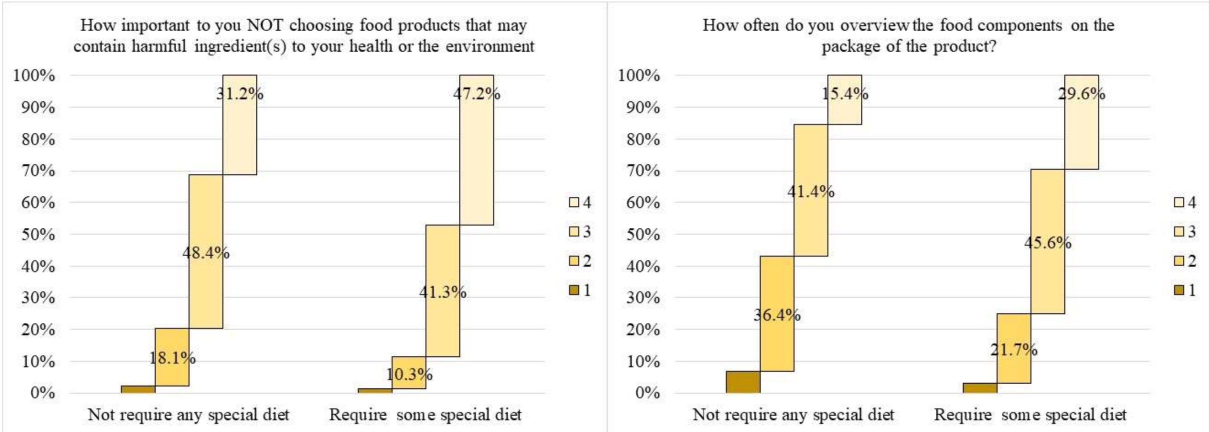

Figure 3. Probability values for the two research questions

Regarding the application, we examined whether a higher proportion of purchaser respondents are interested in applications that are suitable for displaying some product information. Figure 4 shows the result.

Figure 4. Interest in different applications in two groups divided by the frequency of shopping food products

The figure shows that nearly one-third of respondents would be interested in an application, most of whom chose the complex version. In all cases, customers are more interested in applications that support the purchase decision. In the next section, we outline a possible architecture of an application that takes into account, among other things, the following main aspects: code reading, product database, personalization options, and feedback in the user interface.

3.3 Description of a possible system architecture

In the following, a brief presentation of possible system architecture will be presented taking into account some alternative solutions. Based on the known factors, the functional architecture should include three main components which will be described in the order of a typical communication process. As a first step, the client-side or user application has a predominant task of data input (identifier and attributes regarding to the product) and output (simple data query as well as the result of any analysis) using a GUI and imaging unit, however it also stores user-specific data. Based on the presumed user requirement of the system, platform independent operation is an essential attribute that needs to be considered. There are two solutions, including the development of a web-based application, or the development of native applications for each major mobile operating system. The first variant has an advantage of a shorter and more cost-effective development cycle; however, a web browser does not have access to the lower-level classes and functions of the operating systems that are able to decode barcodes and QR codes natively, thus it is required to transfer the image for further processing at server-side using a CNN (Convolutional Neural Network) approach (Li et al., 2018), ensuring robustness, considering the different imaging conditions (lighting, exposure, composition). This results in higher data traffic (due to the image transfer) and additional development requirements at the server-side application. In the case of native application development, the Apple iOS operating system is able to use the “VNDetectBarcodesRequest” or “CIQRCodeFeature” class, while in the case of Android based devices, the “BarcodeScanning” class is intended to use for this purpose, ensuring built-in methods for decoding. In order to decrease the complexity of the client application as well as to gain additional advantages, the applications are supposed to be in direct connection with a REST API (application programming interface) via HTTP protocol. This additional step decreases the required data-traffic, takes over the computational load from the device at the user side, as well as ensures that the user application is not in direct connection with the database (increased security). The API also decreases the development time of the native applications as in this case, only the GUI, a validation and a communication class need to be developed, but the main logic is implemented in the API. On a functional level, the API should be able to handle on-demand (request from the user application) and scheduled tasks. The on-demand tasks include user authentication, input phrasing, analytics, database management and error handling. The transferred data packet should include three major parts, forming different hierarchic levels, including the user validation (session ID), the data (in dynamic structure) and the intended task (the purpose of the data). Due to the fact that the data is in hierarchic format, JSON or XML provides and an adequate structure, ensuring rapid development due to the available phasers. Various factors should be considered while developing the API to data in order to strike a balance between development speed, operating speed, reliability, and scalability. The spectrum begins with a PHP application (Ben Hassen, Dghais and Hamdi, 2019), followed by the current methods, based on NodeJS (Cheng et al., 2018) or Django (Scullion, 2018), up to the native and more complex solutions based on C++ and networking libraries.

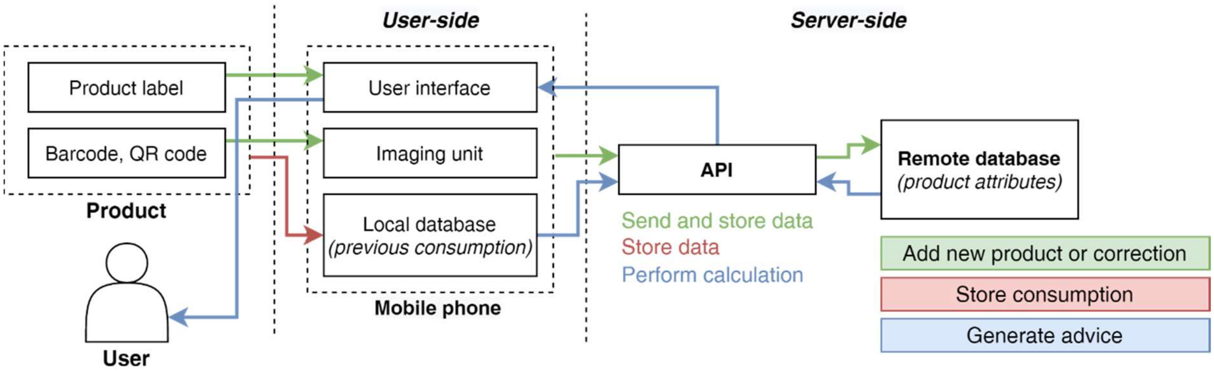

Figure 5. Typical application user/server database connection scheme

Source: own edition

Based on this, we can see that most of the logic is determined on this level. The three main goals is to create a product database (product attributes), to provide the local database (previous consumption) and in addition to the mentioned data management, the data analysis is a more complex task that needs to be performed. Based on the concept, the application can provide feedback to the user regarding a specific product considering how it fits the personal requirements. These requirements can be determined based on previous consumption (taste and preference) as well as based on predefined rules (ingredients to be excluded or minimized). In the following, a possible implementation of the latter option will be described. To achieve this, recommender systems are able to generate recommendations based on profile, interests, and past preferences (Yusof and Noah, 2017). In the food domain, main techniques include collaborative filtering, content-based, knowledge-based and hybrid methods (Vairale and Shukla, 2019). In our case content-based and knowledge-based methods are considered adequate as the former can filter based on the previous choices, while the latter is able to utilize explicitly defined requirements (Bianchini et al., 2017) with the combination of case-based and constraint-based suggestion (Vairale and Shukla, 2019). Current solutions also suggest to use a hierarchical attention mechanism (Gao et al., 2020) as well as standard RNN (Recurrent Neural Networks) or CNN (Convolutional Neural Networks), depending on the specific research (Ouhbi et al., 2018).

The other end of the typical use-case consists of the database and its structure. Based on the initial concept, the user specific and shared data is stored in a different database. User specific data (historical food consumption) is stored locally on the device of the user. However, the attributes (identifier, name, nutritional data etc.) of the specific food.is stored in the remote database which is community-based; thus, every user is able to contribute new records. In case of the remote database, most of the important attributes of a product (UUID of the product, manufacturer, name, quantity, time and date of upload, original uploader) can be stored and normalized in a relational database in a sensible way, however the nutritional attributes are more diverse, thus it is more efficient to use non-relational approach in order to store the related data. If we store these attributes in a single variable, it is possible to dynamically add or leave specific attributes to a product due to the fact that most relational database engines are now supported document-based attributes (JSON) with CRUD operations (Liu et al., 2020). Most of the previously mentioned, possible corrections concern these nutritional attributes. If we store these data in the mentioned non-relational manner, it is possible to store different versions of the whole document (the original and the possible corrections) in a single record, ensuring easier manageability. In case of a community-driven database, specific structure and verification are required to ensure reliability. Some concept uses centralized verification, however in this case, community-based verification seems to be more reliable. Based on the concept, a new record is rated as neutral, however, if a user modifies an attribute of an existing record (checks a product label and states that an attribute of that specific product is incorrect), the reliability score decreases until sufficient correction is performed by multiple users (decreasing deviation of the values). On the other hand, if a record is used multiple times without any complaint and correction, the assumed reliability score increases. Of course, the score should be visible for the user to act accordingly, thus if the reliability is low, it is advised to check the product information before proceeding.

4. Conclusion

This paper outlines on the one hand the evaluation of some important factors in connection with the food composition and the extent of the interest in services available on smartphone applications of the 18-25 age group. On the other hand, we present a description of a possible system architecture for an Augmented Reality application that may be a bridge between consumers and product information supporting personalized food choices that may be healthier and more conscious this way. These types of information are already on the packages in form of logos or marks. However, Augmented Reality (AR) can bring them closer to consumers, drawing attention to important socio-economic aspects.

AR is the melting of reality and cyberspace, that is, the technology adds virtual elements to a real-world environment. This is a real-time visualization technology that allows users to see information about their environment in an interactive way. In the case of a smartphone application, a possible option to use is to apply unique IDs of a certain product by scanning that can display information, even on the base of previously set personal criteria. Barcodes and QR codes are available on packages to scan. Barcodes with an appropriate dormant database can be used by an application to display product information during shopping. QR codes are suitable to display extra information. Basically, they are used to access company web pages and in this case their quality, updating, their design, and their mobile-optimized version are crucial. Furthermore, QR codes can be used, precedents exist, to prevent counterfeiting in case of unique, craft food products.

Our results based on the survey show that respondents who have any need for a special diet are more interested in reading product information. In our opinion, simple but complex smartphone applications may not only motivate them, but further people towards conscious food consumption by increasing user-experience. Approximately one-third of the respondents expressed their interest in using a digital interface designed to support conscious and healthy food choices. Furthermore, since the majority of the responding students (60.1%) typically buy food for themselves, their opinion about food choice can be considered relevant to the development of smartphone applications supporting decision.

We presented a possible system architecture and implementation of it. The three main goals are to create a product database (product attributes), to provide a local database (previous consumption) and in addition to the mentioned data management, the data analysis is a more complex task that need to be performed. Based on the concept, the application would provide feedback to the user regarding to a specific product considering how it fits the personal requirements. These requirements can be determined based on previous consumption (taste and preference) as well as based on predefined rules (ingredients to be excluded or minimized). Regarding the implementation of such an application, we presented some important technologies (GUI, CNN, API, JSON, XML) both at user-side and server-side, in connection with the objectives.

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