PHARA: a personal health augmented reality assistant to support decision-making at grocery stores

Francisco Gutiérrez
Dept. of Computer Science
KU Leuven
Celestijnenlaan 200A
Heverlee, Belgium 3001
francisco.gutierrez@cs.kuleuven.be

Bruno Cardoso
Dept. of Computer Science
KU Leuven
Celestijnenlaan 200A
Heverlee, Belgium 3001
bruno.cardoso@cs.kuleuven.be

Katrien Verbert
Dept. of Computer Science
KU Leuven
Celestijnenlaan 200A
Heverlee, Belgium 3001
katrien.verbert@cs.kuleuven.be

ABSTRACT

Poor diet and physical inactivity are important factors that contribute to the obesity outbreak. Therefore, healthy eating habits are crucial for physical well-being. In this paper, we present the concept design and an early stage evaluation of PHARA, a personal health augmented reality assistant that recommends healthy and similar products to people in their everyday lives. We evaluated a content-based recommender system in a desktop environment (n = 15) to measure the perceived quality, as well as behavioral intentions of users. In addition, we evaluated the user interface and measured participants' perceptions of usefulness and ease of use. Whereas perceived usefulness and perceived ease of use are good, more work is required towards improving the accuracy and diversity of recommendations.

CCS CONCEPTS

•**Information systems** →**Decision support systems;** *Recommender systems;* •**Human-centered computing** →*Mixed / augmented reality;*

KEYWORDS

Decision Making, Recommender Systems, Augmented Reality

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1 INTRODUCTION

Nowadays, recommender systems are increasingly used to support decision-making in health-related contexts, suggesting users how to improve their eating, exercising or sleeping behavior. An example is the use of recommendations as a basis to algorithmically derive balanced meal plans that meet nutritional guidelines for the user [4]. These recommendations are generally based on personal profiles that include gender, height, weight and physical activity, to provide estimates on individuals' basal metabolic rates and daily kilo-calorie requirements. Although we can find relevant literature covering several aspects of food recommendation [1], there is not so much research on the HCI factors of the actual delivery of food recommendations to users. Holding to the principles of just-in-time knowledge management (JITKM)[3], we believe that delivering the right information at the right context has a positive impact on people's food buying decisions and, ultimately, will help them accomplish their health goals. Therefore, we are interested in providing information to people when it matters the most - in the moment of decision: when they hold a product in their hands at the grocery store. Grocery stores provide an interesting setting for our research, as people there make many food buying decisions. To this end, nutrition labels may play a key role in promoting healthy food choices [8], as improving people's diet begins by improving the nutritional quality of the food choices they make. On the other hand, crowdsourced databases such as Open Food Facts[1] provide a big source of nutritional information for food products from around the world, opening a new spectrum of possibilities for relevant recommendations. We want to bring these concepts together along with the potential that augmented reality (AR) technologies have to offer while providing a context-aware, continuous AR experience [5].

2 RELATED WORK

Recommender Systems. van Pinxteren, Youri *et al.*[12] implemented a similarity measure for recipes based on a collaborative filtering approach. The similarity measure can be used to promote new recipes that fit into people's lifestyle according to their preferences. Shekar, Sangeetha *et al.*[10] propose a traditional content-based implementation using a phone grocery shopping assistant that recommends products based on the user profile and a database of products. Achananuparp, Palakorn, and Ingmar Weber [1] explored healthy food recommendations by finding food substitutes in similar contexts using a crowdsourced service.

Visualization. The work of C. Siawsolit *et al.* [11] illustrates the use of a simple star-rating visualization to suggest healthy products and how a nutritional-based recommender system may be useful to people who are motivated to eat healthy but have no time to compare products. Many alternatives rely on a simplified nutrition labelling system to help consumers make healthier food choices. A prominent example is the five-colour nutrition label/nutri-score

[1] https://world.openfoodfacts.org/

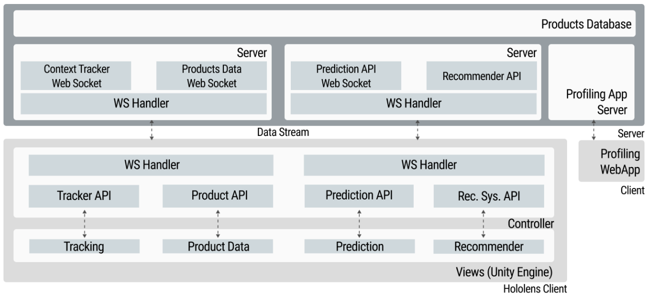

Figure 1: Architecture of PHARA that illustrates the different components of the system and the communication between server and clients.

based on the British Food Standards Agency Nutrient Profiling System (FSA-NPS), which is an score calculated for each 100g amount of energy, sugar, saturated fatty acid, sodium, fibres, proteins, and fruits and vegetables.

Augmented Reality. The most comparable system to PHARA is the work of Ahn, Junho *et al.*[2] who developed a handheld AR system that uses color-based AR tagging to support people in finding healthy food products in supermarkets. Their application uses an in-store navigation system to guide participants to the products and shows a single color-based label to highlight information over the product. While this system may be the most similar to PHARA, we are interested in the usability of immerse scenarios in which users have both hands free to interact and get information from the system, in a just-in-time fashion. On the other hand, in contrast with the work of Ahn, Junho *et al*, we are interested in more deep recommendations related to the context of both the product and the user. To this end, item-item content-based recommenders have the potential to leverage personal data while letting users explore the relationships between food products and health-goal achievement.

3 SYSTEM DESIGN

The design of PHARA is inspired by related work, JITKM goals, personal health tracking challenges and the opportunities presented by recent advances in AR head-mounted display (HMD) technologies, such as Microsoft Hololens[2]. In this section, we describe the system architecture and the design of PHARA's user interface.

Architecture. The architecture of PHARA is shown in Figure 1. We envision an immersive system where users can wear the HMD freely and execute tasks using input such as voice commands or hand gestures. With a reactive design[3] in mind, data is streamed on demand from the servers to ensure system responsiveness. Computing of recommendations and predictions take place in the server, releasing the HMD from any other computation other than tracking and recognizing printed labels and barcodes to identify products. A Web Application also is served in a separate client, through which users can introduce and synchronize their devices with personal data.

[2]https://www.microsoft.com/en-us/hololens
[3]http://www.reactivemanifesto.org/

User Interface. The interface of PHARA is inspired by the work of Heun, Valentin *et al* [6] in smarter objects, and we also considered following Matthew Kay[7] suggestions for personal health visualization design. In Figure 2 we present an early digital prototype of our interface that uses an AR card component layout to show: a) a visual component of *Similar Products* recommendations; b) an *Impact on Health* component that gives a prediction of the impact of the product on user's health; and c) an overview visualization of the product that shows a description of the nutrients in an intuitive visualization.

4 USER STUDY DESIGN

In this section, we present the design of our user studies. Results are discussed in the next section. We recruited 15 participants (3F, 12M; mean age: 27.6, SD: 5.88) via word-of-mouth. We asked them to participate in two studies to collect their thoughts towards the recommender system, and an early paper prototype to understand how PHARA can be used in real world settings. A short offline evaluation was conducted afterwards to test recommendation accuracy and diversity.

Study 1: Recommender System. We built our system using a crowdsourced database from Open Food Facts, using a content-based approach and a similarity index to estimate similarities between food products. We generated recommendations based on similarities of products to provide recommendations about *Similar Products*, *Healthy Products* and *Based on your Profile*. Participants were presented with a Web browser application where they were required to create a profile with their personal data (allergies, height, weight, age and activity level). Afterwards, they were asked to select 10 favorite products to train the system. After creating a profile, a dashboard was shown (see Figure 3) were they could see a list of recommended products. The task was as follows: *Select any products that you would like to have for dinner.*

The system showed a visualization of "MyPlate", with suggested indications for a balanced meal, based on Healthy Eating Plate created by experts at Harvard School of Public Health and Harvard

Figure 2: Early digital prototype that illustrates the visual card components of the application a) Recommendations, b) Health Impact Prediction, c) Product Information.

Medical School[4]. Participants had to add products until they were happy with their selection. When clicking on a product from the list, the system showed the product information and three lists, *Similar Products*, *Healthy Products* and *Based on your Profile*, each including six recommendations. After finishing their selection for a healthy plate, we asked users to fill out the ResQue[9] questionnaire to understand the user experience with the recommender system.

Study 2: Paper Prototype. We presented packages of different food products from the local supermarket to the participants on a table. We reused the design of the components from Study 1's application and printed them on paper, see Figure 4. Participants were informed about the AR system and the concept in general. We also created cards with recommendations from the system, based on similar products and healthy alternatives. Participants were asked to think-aloud their ideas during the experiment, and to imagine the following scenario *you are in the grocery store and you want to get a selection of food products you would likely buy*. The task started with participants picking up any product from the table and then, as PHARA would (automatically) do, the corresponding detail component card (Figure 2c) was manually attached to the front-side of the product package. When participants asked for recommendations of healthier or similar products the corresponding recommendations card (Figure 2a) was attached to the package and we asked them to pick one of the recommended products from the table. When they did so, and while holding both products, we attached the corresponding product detail card (Figure 2c) to the newly picked product. Afterwards, we asked participants to compare the products using both the printed information in the box and PHARA's detail cards and chose the one they would likely buy. We repeated this procedure until participants declared they were satisfied with their selection. At the end of the task, we asked participants to fill out a technology acceptance questionnaire [13].

Study 3: Offline Evaluation. An offline experiment was conducted by collecting activity data of the users that used the Web application recommender system. Using this data, we calculated the proportion of the recommendations that were actually suitable for the user (precision) and the variation of items in the recommendations (diversity) of the system.

[4]https://www.hsph.harvard.edu/nutritionsource/healthy-eating-plate/

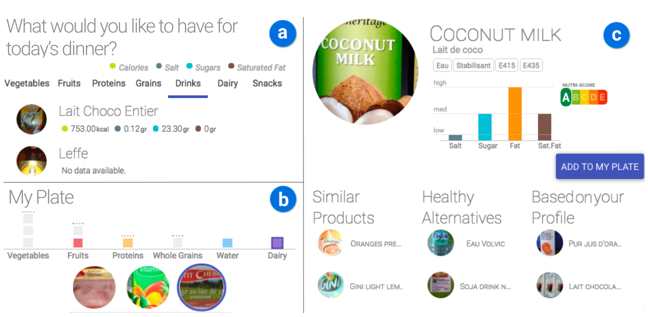

Figure 3: Components of the Web Application used to Evaluate the usability of the recommender system. a) Product Navigator, b) My Plate, and c) Product details and recommendations.

Figure 4: Participants during the studies using the desktop application to evaluate the recommender system and using the paper prototype.

5 RESULTS AND DISCUSSION

Recommender system. We summarize the results of Study 1 in Figure 5. Participants indicated they perceived the system as useful ($Median = 4$) on a 5-point Likert scale (one: strongly disagree, five: strongly agree). They also indicated that they were familiar with the products in the database ($Median = 4$). The interface that was shown to them appeared to be adequate ($Median = 4$). Other factors such as confidence, novelty, satisfaction and behavioral intentions tended to be rated lower ($Median = 3$). The main comments of the participants at the end of the session were related to the quality of the data which is reflected in their behavioral intentions ($Median = 3$), indicating that some products were not easy to find due to missing information about the product. There were also comments related to the diversity of recommendations ($Median = 3.5$), indicating that similar products appeared too often in the recommendations.

Paper prototype. Results are presented in Figure 6. Participant feedback tended to be positive in general ($Median >= 6$) on a 7-point Likert scale (one: unlikely, seven: likely), indicating that they found the system to be intuitive, easy to use and learn. However, some participants were concerned about the flexibility of use ($Median = 5$), given the HMD hardware that they would wear with

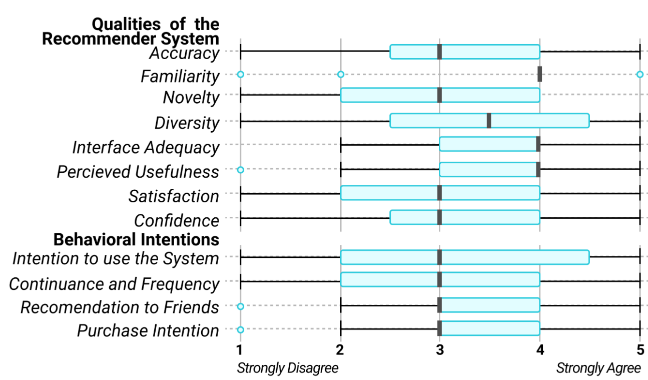

Figure 5: Perceived qualities of the recommender system, and users' behavioral intentions.

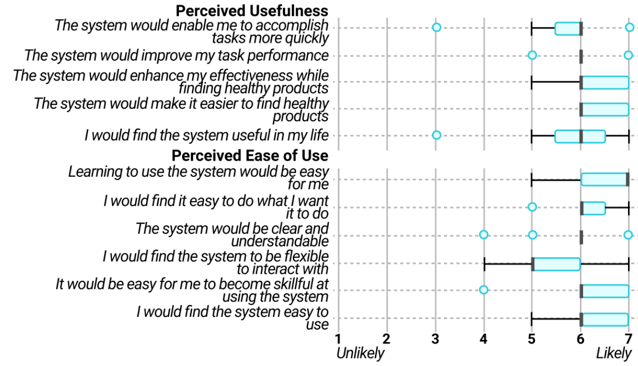

Figure 6: Participants' perceptions of usefulness and perceived ease of use of PHARA.

the real HDM device. Some participants had comments during the think-aloud session *"The information cards look intuitive and easy to read, however more details on the object would be useful"*. When asked to compare the information printed on the box with the augmented component, a participant mentioned that *"Actually, this component complements the information in the box"*. When asked to hold both products and compare them, a participant mentioned: *"In this way, it is easy to compare both products, the information is consistent. Sometimes reading the package can be misleading and/or difficult to read"*.

Offline Evaluation. Our initial test showed that recommendations had a low precision and recall, (see Figure 7). However, the numbers for *Healthy Alternatives* also illustrate the interest of participants in healthy products. These metrics illustrate participant's feedback in study 1, where they indicated that recommendations of products seemed to be useful, but factors such as accuracy and diversity were an issue. This was noted particularly when participants faced incomplete descriptions of food products, or missing values. Participants tended to stick with familiar or similar products that they felt confident with. Crowdsourced databases present a lot of opportunities by providing a large set of items supported by a devoted community of users. However, uncertainty in data quality is a challenging factor in terms of processing and presentation to the end user to be addressed.

6 CONCLUSIONS AND FUTURE WORK

We have introduced PHARA, an AR system to support decision-making at grocery stores and described the results of three preliminary user studies. The obtained results are encouraging and suggest that PHARA's concept is likely a viable way to promote the adoption of healthy food buying behaviors. Future work will refine the prototype and explore its effects in larger and more diverse audiences and settings. We will explore different strategies to improve diversity and precision of food recommendations in future studies and different visualizations will be evaluated on how to effectively communicate personal health data to users.

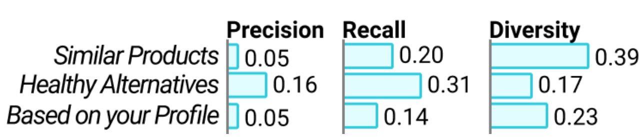

Figure 7: Precision and diversity of recommendations.

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