Augmented Reality Based Recommending in the Physical World

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Abstract

Recommender systems have received the attention of the scientific community for a long time now and they have become a daily tool for internet users. Nonetheless, they are not commonly applied to physical settings, where having access to recommendations could be of great benefit, specially when combined with item comparison capabilities. Due to the latest augmented reality technology advances, it is possible to bring these concepts together. An intuitive action like visually comparing two products could be enhanced by 3D cues and suggestions. In such terms, we discuss the possibilities to improve the item exploration and decision-making stages of the recommending process by providing item comparison supported by 3D augmentations, offering a novel contribution to both augmented reality and recommender systems domains.

1 Introduction

Recommender systems (RS) have become an everyday tool that most internet users know and benefit from (Ricci et al., 2011). They cover a wide range of domains due to their proven usefulness and the extensive research behind them. Furthermore, popular websites and applications offer them as a main part of their services, many of which could not be conceived without them (e.g. Amazon, Trivago). Effectively communicating to the user the reasons behind a given recommendation has proven to be crucial for increasing the system's transparency and trustworthiness (Sinha and Swearingen, 2002). Many methods to enhance transparency have been researched, relying mostly on textual explanations or the way items are presented (Tintarev and Masthoff, 2007). In conjunction to RS, it is also common for online retailers to offer product comparison tools to help users during the decision-making stage.

RS have been largely used in digital settings, but they are rarely applied to real world contexts, despite their potential to be equally valuable when dealing with physical objects. Nonetheless,

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recent advances in augmented reality (AR) technology allow new interaction methods, bringing opportunities to employ RS theory to physical world situations, where recommendations and the real world objects they concern are presented together in a shared space. How these recommendations are shown and what interaction methods should be used to manipulate them are still open research questions.

When in a physical store context, it is particularly interesting to observe how clients behave if no external information source is at hand (e.g. RS, expert opinions or user ratings), so that the customer must rely on what it is provided by the products themselves (e.g. their appearance or a technical data sheet next to them). In such situation, customers tend to focus on product characteristics, in a decision-making process that requires comparing attributes of different products against each other or against the client's own preferences (Lancaster, 1966). Comparison is one of the most basic cognitive activities and plays an important role in understanding, discovering and evaluating our surroundings (Gentner and Medina, 1997). Nonetheless, retaining product characteristics can be a big constraint when comparing several items (specially when they are not side by side), issue that is accentuated by the limitations of short-term visual memory (Alvarez and Cavanagh, 2004). It has been proven that AR alleviates the mental workload of retaining information by eliminating short-term memory demands by using spatial superimposition (Tang et al., 2003). When combined with a RS, this approach would support the recommending process during the item exploration and decision making stages, improving the comparison action and enhancing the way a user inspects products and their disparities/similarities.

In this paper we present our ongoing research regarding AR supported comparisons in the field of RS, where previous work is introduced and further research discussed.

2 Related Work

AR has received a great amount of attention lately, mostly due to its recent consolidation as an approachable technological choice (Chatzopoulos et al., 2017). In a few cases, RS and AR have been coupled already for product recommendations in brick and mortar stores. Examples of it are PromoPad (Zhu and Owen, 2008), which deepens in the concept of dynamic product contextualization to provide suggestions, and PHARA (Gutiérrez et al., 2017), where an AR system oriented to promote the adoption of healthy food buying behaviours is presented.

Supporting product comparison is a common feature in online retailers, where the characteristics of different products are shown side by side. In the field of RS, critiquing-based recommenders allow users to receive new recommendations by modifying specific feature values of the current, given ones, thus performing a direct comparison (e.g. a film with more action, a car with less gas consumption). Interesting in terms of visualization, Zhang et al. (2008) studies the benefits of using a visual interface which presents critiques of several items at once by displaying icons instead of text.

To the best of our knowledge, visually expressing feature differences and/or similarities of two or more physical objects has not been studied in conjunction to RS and AR yet, although visual

comparison research made in other areas might serve as starting point, like studies addressing the comparison of graphs (Gleicher et al., 2011) or maps (G. L. Andrienko and N. V. Andrienko, 1999). In Tominski et al. (2012) a system that supports the comparison of information printed on paper is described, reporting the benefits of using natural interaction methods.

3 Combining AR and RS: Research Status

We aim to study the benefits of providing recommendations supported by AR in a physical store situation, being of great importance to investigate how to convey and interact with product information (whatever it may be) in the virtual world in a comprehensible, natural manner.

In the following, we first present an early approach to our research, where we explore the feasibility to use a virtual advisor that guides the user and provides insight on why products are recommended. After reviewing the lessons learned, a new research direction targeting product comparison visualization is discussed.

3.1 The Initial Study: Product Explanation + Virtual Advisor

In a first attempt to use augmented reality in the field of recommender systems, we developed an application running under Microsoft's HoloLens that is able to recognize a number of physical printers and provide recommendations after collecting the customer's preferences. Multimodal, natural interaction was a priority, enabling natural language recognition (via Google's Dialogflow), selection through gaze and air tapping, as well offering feedback in the way of 3D augmentations, text and text-to-speech. A main focus of the research was to explore product explanation through AR in RS, accomplished by the usage of an embodied virtual advisor (Fig. 1) and virtual augmentations of the products (Fig. 2).

Figure 1: Virtual advisor.

The virtual advisor provides guidance through the buying process, giving under request information relative to the products (e.g. price, availability of features). It also gives instructions

Figure 2: Using augmentations to explain how to refill a printer with paper.

about how to operate a printer (e.g. how to change a cartridge) while at the same time augmentations of the products are shown, visually enforcing what the advisor says. Product explanation is meant to support the buying decision process, being useful in situations where the way a specific operation is conducted is relevant for the client's choice (e.g. finding a product that is controlled in a similar fashion to a previously owned one).

If asked to, the advisor will give content-based recommendations, for which the preference elicitation is carried out in a conversational manner through a number of questions (e.g. are you looking for a printer for your home or your office?). Once a recommendation is given, a user can inquire about the reasons behind it, for what the advisor will expose how the chosen printer matches the specified requirements. If the user is not convinced, it is still possible to critique some of the printer's features to receive a new recommendation.

3.1.1 Outcome

We conducted a small user study (N = 15) from where we soon realised the existence of usability issues. Two important lesson that we learnt were that:

- **The number of information sources should be kept as low as possible, fitting on the screen and anchored to real world.** Splitting the action and information sources proved to be harmful to the experience. The virtual avatar and the information overlay displayed on the printers were not visible at the same time, breaking the immersion and disorienting the user, who in many cases did not know where to focus the attention. Furthermore, the avatar position was lost quite often, due to the lack of a physical anchor.
- **The use of AR technology only makes sense when it adds something unique that cannot be reproduced by any other alternative means.** Keeping consumers' fidelity and willingness to use AR solutions has been referred as an issue already (Chatzopoulos et al., 2017; Hopp and Gangadharbatla, 2016), the main causes being that a) the sense of novelty fades away quickly and b) the existence of other methods that provide a similar service without causing the physical fatigue of holding a camera or wearing special

equipment. Specially in the context of e-commerce, there are examples of mobile applications capable of recognizing products and giving recommendations in a similar setting than the one presented here, which means that in most cases users will try an AR approach out of curiosity, but will not stick to it.

3.2 Current Work

Because of the findings of the first study, the focus of our current research has taken a slightly different direction. While overlaying usage explanation on products is something that cannot be achieved by any other technology aside from AR (bringing an added value per se), our goal is far beyond providing such explanations and the effort of creating them should be minimized. Nonetheless, being able to see differences between products (respecting their usage or any other matter) happens to be very useful knowledge when deciding which one to buy. Following this idea, the research now pursues the goal to investigate how to use AR to directly perceive discrepancies among physical products that are not obvious at plain sight or that require to be consulted on a separate information source to know them. The advantages of using an embodied virtual advisor in this scenario remains an open question, although natural language recognition seems to be a valuable feature. Ultimately, these ideas will still be built on top of a RS, improving item exploration and helping during the decision making stage. In addition, the new concept brings to the light several new questions:

- **What kind of data is useful for a comparison?**
  Traditionally, websites that provide comparing tools simply list all their attributes side by side. AR is a more powerful communication medium, but it has its own restrictions. It is critical to use the right visualization means to report a comparison (text, highlighting parts of the object, animations, navigation aids) while at the same time avoiding to overcrowd the view with too many information sources. Filtering down what to show (also taking into account the user's preferences) and when to do it gains greater significance.
- **How to visualize a comparison of an out-of-sight object?**
  A system that aspires to show dissimilarities among two or more physical objects will have to deal with the fact they will not always be on-screen. Therefore, it is fundamental to study how to keep track of what is being compared and how to translate the comparison to the user in a comprehensible manner.
- **How should interaction be carried out?**
  Studying how humans intuitively behave when comparing objects could be beneficial in the creation of interaction methods that feel effortless and natural. As an example, when using a platform that allows free hand movement (like a head mounted display) the comparison tool could recognize when a user is holding a product to take a closer look to it, consequently augmenting it to display significant data (Fig. 3).
- **How to identify characteristics of suitable product domains?**
  Finding a domain where these concepts perform well might not be an easy task. Small, full of details an easily distinguishable objects are preferred. Also, expert knowledge and

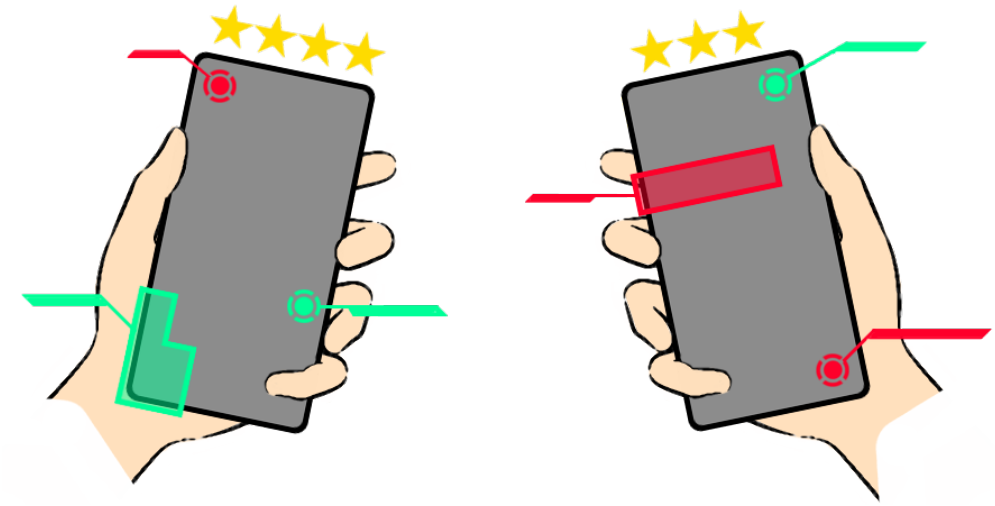

Figure 3: Concept for an AR comparison tool.

technical data should be needed to make a good choice, so that recommendations are welcomed by the user and it feels worthwhile to utilize comparison aids.

4 Conclusions and Further Research

In this paper we have discussed the possibilities of using AR in conjunction to RS. A previous approach is firstly discussed, where recommendations are offered by an embodied virtual advisor, providing as well product usage explanation via 3D augmentations and exploring multimodal interaction. After the findings of this first attempt, a new research direction is presented, focusing on the feasibility of creating a visual comparison aid for physical products, its possible benefits when combined with RS and the new challenges that come along with them. In the near future, we aim to define a number of interaction and recommendation models that could work well with our approach, put these ideas into practice by creating various prototypes and conduct the corresponding user studies to evaluate them.

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