Automated Augmented Reality Content Creation for Print Media

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Abstract The widespread diffusion of mobile technologies enables to reach a multitude of virtual contents, which crowd the infinite space of the internet: a huge extension that could not be transferred into a paper-based medium. Nowadays, traditional print media must face the growing diffusion of internet-based media. An opportunity to face the decreasing trade of paper-based media is provided by Augmented Reality (AR). The creation of Mixed Reality (MR) environments seems to offer the possibility to build a bridge between real and virtual, between print media and internet-based media. However, the integration of AR and print media still needs to deal with the issue of the automated content creation. In this paper we bring into focus the problem of the lack of automation in hybrid media and we propose a different paradigm, which results useful to design new editorial models. Furthermore, the system that we defined enables the creation of individualized reading experiences through the integration of a recommender system. By means of the definition of the domain ontology of the system, we have been able to define a prototypical implementation of the described automated AR content creation process, in order to demonstrate the feasibility of the proposed approach.

Keywords: Mixed and Augmented Reality, Print Media, Hybrid Media, Individualized Interface, Recommender System.

1 Introduction

The increasing market of internet-based media gives a hard time to the market of traditional print media. The large diffusion of smartphones enables the possibility to reach the wide-spreading space of the internet, with rapidity and simplicity. The finite space of print media appears sentenced to a definitive decline and the possi-

bility to define a connection between internet-based contents and print medium represents an engaging challenge. Smartphone users are getting more familiar with the concept of virtuality, notion that on the screen of a mobile device seems to be even tangible. The definition of a mixed reality environment for print media through the integration of AR tools offers an interesting perspective to shape the concept of hybrid media as a possible "third way" in the duality internet-based media/print media. However, hybrid media systems must be further investigated in order to face specific research questions.

1.1 Motivation

One of the main challenges regarding the integration of AR systems into print media is represented by the lack of standardization. The absence of univocal AR browsers doesn't deal with the need of automated content creation processes for hybrid media. If the effort to reach the standardization of AR browsers seems to require a big player with a consistent critical mass [1], on the other hand the possibility to define automated processes for the AR contents creation represents an affordable research question. The development of MR environments for print media may guarantee to the users new reading experiences and a high degree of immersion in the reading [2]. This aspect ensures a real and tangible advantage for the publishing companies in terms of feedback and impact on the costumer. Aimed by the generalized lack of automation and standardization of traditional AR systems for print media, in this paper we present a system which is useful to generate automated AR contents by means of the integration of a recommender system. Furthermore, the recommender system enables the generation of individualized recommendations, which are able to provide a consistent added value to the presented MR system.

1.2 Methodology and paper structure

The contributions of the paper can be summarized as follows:

- Introduction of our concept and motivation of the need to consider new hybrid editorial systems, which are able to perform a persistent modification of the modalities of use of print media. The automated content creation process that we show enables the detection of relevant virtual contents, which are necessary to generate an up-to-date AR app for every release of a print medium. Specific user related recommendations are then integrated into the AR system in order to enable an individualized reading experience.
- Brief exploration of the status quo of AR based hybrid media. We introduce examples of integration of AR tools in print media and we present some of the possible technical modalities to integrate virtual contents in paper-based systems with mobile devices.
- Description of the architecture of the system. The framework that we defined is oriented to the creation of an AR app, which is based on our concept and integrates an individualized recommender system. The recommender system suggests relevant editorial contents but it also works as a search engine: it has the

task to suggest appropriate contents and to detect relevant virtual contents, which may become AR contents.
- Presentation of the implementation design. Our work has been developed according to a specific knowledge framework derived from the domain ontology that we developed for the specific MR environment of the system. We examined different use cases to describe the knowledge framework of the hybrid media model that we present and we point out the specific use case related to editorial articles. In this way we can show the automated and individualized content generation process that we defined.
- Presentation of the prototypical implementation and evaluation of the artifact.
- The paper concludes with the synthesis of the achieved results, a short outlook and a discussion of future work.

According to a design science research approach [3], our research has to follow seven guidelines to be rigorous and relevant. The automated recommender system, which is integrated into the described hybrid media system to detect and create AR contents represents the innovative and purposeful artifact (Guideline 1) and it finds its expression in chapter 4.3. The introduction chapter specifies the relevance of the research problem and the problem domain (Guideline 2). The aspects concerning the evaluation of the artifact (Guideline 3) are considered in chapter 5. Moreover, we dedicated a chapter to the description of a first prototypal implementation of the presented system, in order to show the feasibility of the system and its innovative strength (Guideline 4). Chapter 1.2 shows the respect of a rigorous methodological research approach, which reflects the coherence and the consistence of the artifact (Guideline 5). Considering the design science as a search process (Guideline 6), in chapter 2 we show that the presented approach considers the relevance of previous related work. The purpose to permit the communication of the research (Guideline 7) is expressed by our intention to publish this paper.

2 Related Work

2.1 Augmented reality and print media

One of the first examples of integration of an AR system into a print medium is represented by the "MagicBook" [4]. The MagicBook is a prototype of an AR book that permits a reader with HMD to explore 3D models during the reading of a print medium. Although this AR system has a considerable importance in terms of research, it also presents some limits: the use of HMD reduces its diffusion in large scale and the use of AR markers as trigger entities limits the printing area of the text, aspects that reduce considerably its business potential. Other examples of integration of virtual reality and print medium consider with a forward-looking vision the use of mobile technology. The German magazine "Süddeutsche Zeitung Magazin" [5] created one of the first AR apps useful to integrate a release of the

newspaper with virtual contents. The reader can experience the enhancement of contents of some selected printed images just scanning the print medium with a smartphone. The success of this example of AR tool for print media was, in terms of downloaded apps, really high [6] and similar experiences have been performed by other editorial companies (e.g., "Stern" [7], "Auto Bild" [8], "Welt der Wunder" [9], "Rheinische Post" [10], etc.). Relevant examples of paper-based AR applications stand out in the field of advertising. These applications are not only limited to the field of the publishing industry but they regard more in general the field of paper-based media, like for instance the packaging industry [11] and commercial leaflets [12]. An interesting research demonstrates that the average reading time of a paper-based AR advertisement is 12 seconds [13]. The average reading time of a traditional printed advertisement is instead 3,9 seconds [14]. It means that the users are generally more engaged and they are more available to pay attention to the proposed advertisements if they are involved into MR environments.

2.2 AR app generation tools

The use of AR technology to integrate print media is certainly dependent on the existing IT tools useful to develop AR systems. The spectrum of technical possibilities gets wider very fast and the offer of AR tools grows rapidly. Nowadays several IT tools offer the possibility to create AR applications (e.g. Metaio SDK [15], Vuforia AR SDK [16], Wikitude SDK [17], etc.). For their own nature, augmented reality and print media may be easily integrated. The necessary presence of a physical print medium useful to transmit the information enables the integration of trigger entities directly on the print medium. Images such as Matrix Barcodes (e.g., QR-Code, Aztec Code, Data Matrix, etc.), AR Markers or textured images may be easily printed on the print medium and used as trigger entities. Additionally, different typologies of trigger entities permit to access virtual contents by means of AR applications. Trigger entities may be for instance simple physical objects, in feature detection based AR systems [18]. Moreover, innovative techniques such as OCR-tools [19], encoded paper [20] or text patch recognition [21] may be involved to create AR systems.

2.3 Research contribution

Even if the possibilities offered by hybrid media are not confined only in the domain of augmented reality [22], mixed and augmented realities represent a key tool to permit the development of hybrid contexts and to maintain a fluid interaction between the different environments [23]. The use of AR technologies and print media results usually sporadic and does not represent a persistent modification of the typology of the offered editorial contents [24]. The use of AR tools in print media doesn’t implicate the integration of virtual contents into print media. In order to integrate virtual contents into print media through the creation of specific hybrid media systems, it is necessary to provide the periodical publication with a periodical up-to-date AR app, which is realizable only through a structured and automated app creation process. To make the AR app generation process

completely automated, it is necessary on one hand to define a process which enables the correct interaction of the different components of the system, in order to create the app itself and on the other hand, it is necessary to define a correct content generation process, which must be of course automated. The analysis of the literature shows the relevance of the integration of automated content generation processes for AR contents. The automated AR content generation process is in particular the result that our research wants to show in this paper.

3 Architecture of the System

We developed a specific automated process to create a hybrid media model which is tailored on the needs of an existing publishing company, in order to consider the validity of the defined paradigm of automation and to test our concept. In this chapter we shape the core building blocks of the system: publishing system, recommender system, external services, BPaaS platform, AR app.

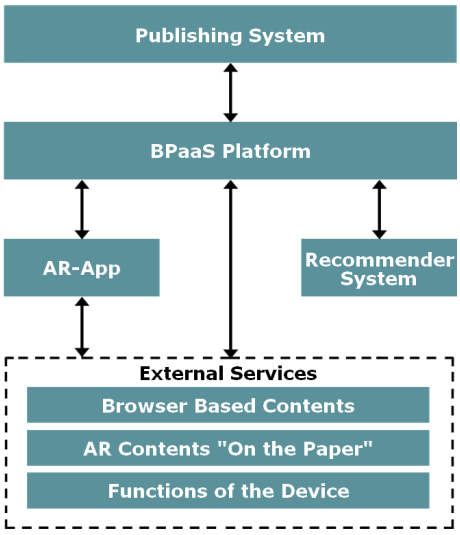

Fig. 1. Architecture of the system

3.1 Publishing system

We proofed our concept with the editorial company "Saarländische Wochenblatt Verlagsgesellschaft mbH (Wochenspiegel)", which publishes a free of charge weekly distributed publication and it offers every week 15 different editions for the coverage of a German region. The existing editorial process can be summa-

rized in two phases. In the first phase, all contents are created and selected for a specific issue of the newspaper. In the second phase, all selected contents are registered in the publisher system. In this way, it is possible to elaborate a large quantity of different contents. Editorial articles are archived in the publishing system through text files, image files and an XML index. Commercials are archived by image files and classified ads are archived through text files, image files, XML index and a database suitable for the online search.

3.2 Recommender system

The purpose of the recommender system is to provide appropriate suggestions to both user and actors of the publishing process. Suggestions are strict related to the profile of the user and to the editorial contents. The profile of the user is gained by implicit feedback (e.g. usage behavior) as well as explicit feedback that users can proactively submit to the app. Moreover, the recommender system has also the important role to make automated the whole AR content creation process. On this line, the recommender system works as a search engine: it detects relevant information in the text of an editorial article. This information are then elaborated and automatically elected as potential AR contents.

3.3 External services

The app creation process determinates the selection of specific virtual contents related to printed editorial subjects. These virtual contents are available in the MR environment generated by the app, in form of AR contents. Links to external services such as the online version of the newspaper, video-sharing websites, web mapping services, social media and other URLs are directly overlaid on the newspaper. They can be virtual contents shown through the use of an internet browser, virtual contents shown as AR entities directly on the view of the print medium or they can be functions of the device, such as the possibility to call a phone number related to an editorial content. They represent a high customizable component of the architecture of the system because they are subject and release related.

3.4 BPaaS platform

The BPaaS platform is an online based platform developed by the project partner Scheer Management. In the general context of the Business Process as a service (BPaaS), this platform permits the technical implementation of individualized IT tools for business processes. The BPaaS platform is responsible for the generation of the AR app.

3.5 AR app

The AR app is the interface through real and virtual environment. Downloading the index of every release, the AR app is always actualized. Therefore the user can experience a different modality of reading of the newspaper, which enables a real-time actualization of paper-based contents. Different typologies of recommendations are integrated in the MR environment created by the AR app. Every release has specific hybrid contents and every content permits to provide personalized recommendations according to the specificity of every reader.

4 Implementation Design

4.1 Knowledge framework (domain ontology)

The knowledge model of the system has been shaped according to the definition of Reality–Virtuality Continuum [25] and it represents a concrete application of this theoretical definition. The development approach has been leaded according to the following methodological process [26]:

- Determination of the domain and scope of the ontology through the definition of specific competency questions [27].
- Enumeration of important terms in the ontological domain through a brain-storming process.
- Definition of classes and class hierarchy through a top-down development approach [28].
- Definition of the properties of the classes and the relationships between them.
- Iterative and deductive reprocessing according to the specific requirements of the system (e.g., the definition of "browser based virtual contents" reflects the requirement of the AR app to use third party contents without having direct responsibility on the contents).

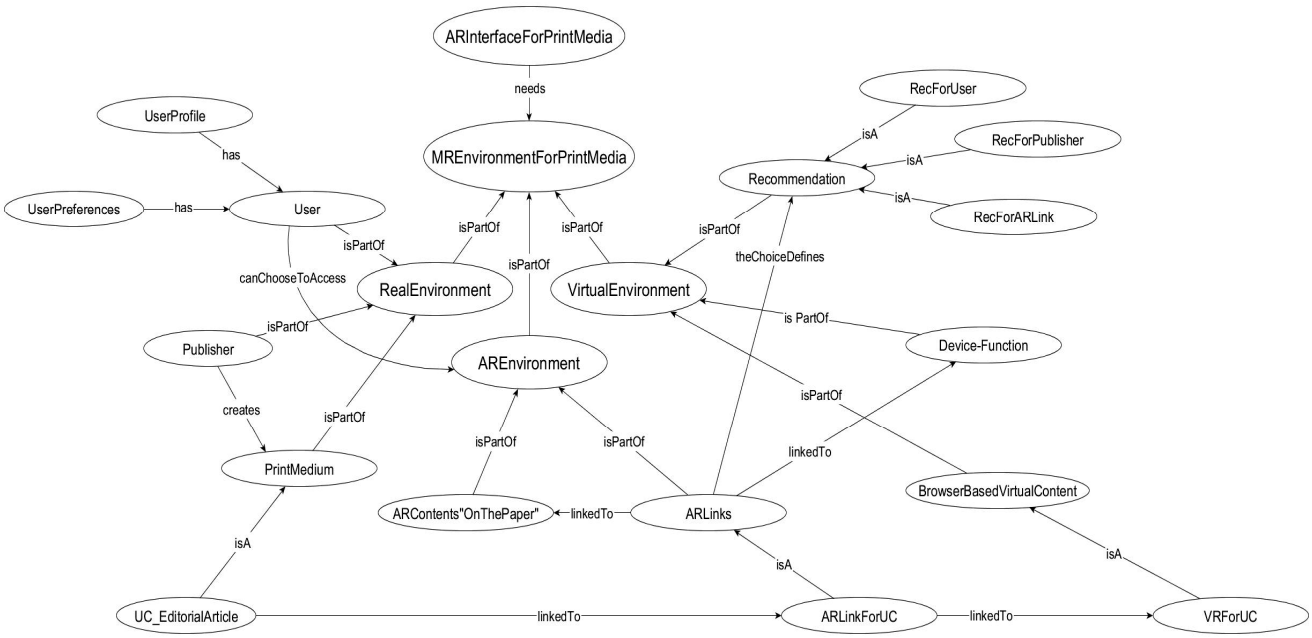

Fig. 2. Ontology of the system

The knowledge model which is the basis to define our concept is expressed by the domain ontology presented in Fig. 2. The creation of a hybrid media system requires the definition of a MR environment. A MR environment is a context where real and virtual worlds merge together to enable the coexistence and interaction of physical and digital objects [29]. The definition of a MR environment is the necessary condition to permit the creation of an AR interface for hybrid media. The hybrid media model that we present develops itself into three different environments: real environment, AR environment and virtual environment. The real environment is the tangible world of print media, which is composed by a publisher who creates a print medium, different users who read the print medium and have peculiar preferences and profiles and of course by a print medium. The difference between AR and virtual environment is defined by the presence in the AR environment of a coexistent and integrated component of tangible reality. AR environments imply a fixed reference with physical objects whereas virtual realities develop themselves through only digital objects. Reading a print medium, users will be able to deepen the editorial content just scanning it with the camera of a smartphone. Virtual links are superimposed on the real time streaming view of the camera and they enable the connection between print based contents and virtual entities. Clicking specific AR links, the users can access different virtual contents. Several typologies of contents may be included in this hybrid environment: galleries of photos, hyperlinks, videos but also individualized services like virtual recommendations.

Different scenarios represent typical editorial contents for print media. We identified the editorial articles as use case to test our concept. Every editorial article which has to be implemented with AR contents has a print based component as trigger entity to access specific AR links in an AR environment, when a user films the print medium with a smartphone. These AR links enable the user to experience virtual contents directly on the print medium (AR contents such as videos, galleries, info or 3D models embedded and visualized on the print medium). Moreover, AR links enable the direct opening of browser based virtual contents and enable to interact with functions of the mobile device.

When a user selects a particular AR link, s/he automatically expresses her/his preferences and her/his profile will be defined. According to user's profile and user's preferences, a recommender system provides appropriate and relevant recommendations about the content of every chosen scenario [30]. Specific recommendations for specific actors of the publishing company (publisher, journalist or content manager) can be provided during the phases of creation of editorial articles in order to receive suggestions and further information about different articles that may treat the same theme. These kinds of recommendations do not depend on user's profile and user's preferences but they are only defined by the content of print based editorial articles.

4.2 Use case: editorial articles

Fig. 3. Representation, from the point of view of the user, of the hybrid media system which links reality and virtuality through the definition of an augmented reality environment.

In our concept, we identified a use case that results useful to proof the automated AR content generation process. This use case refers to the editorial articles. As soon as the trigger entities let the augmentation of the print medium start, the user can see related AR links superimposed on the articles. Print medium and AR links are univocally correlated and filming a specific article, it is possible to detect automatically its own AR links. These links enable to access several virtual contents. AR links related to this use case are divided into two categories.

The first category is composed by the AR entities which connect to browser based virtual contents (e.g., the online article, external websites, etc.). These kinds of AR links are able to open a browser and to conduct the user to specific internet-based contents. When a user chooses to open one of these links, s/he automatically expresses her/his interest in the topic of the article. Therefore it is possible to deduce preferences and profile of the user and to provide, through the integrated recommender system, appropriate recommendations about similar editorial contents. These recommendations are shown in a context of virtual reality. The second category of AR links enables the interaction between AR interface and functions of the mobile device. For instance, the user who reads an article where it is present the date of a coming concert will see superimposed on the print medium an AR link useful to save the date on the calendar of the mobile device.

The user experiences the contemporary presence of virtual entities (VR recommendations, browser based contents and device interactions) and AR entities (AR links and virtual objects superimposed "on the paper") just using a smartphone during the reading of a print medium. In this use case, the recommender system provides specific recommendations useful to support journalists, publishers and content managers during the phase of creation of an article. These kinds of recommendations help them to detect older pertinent articles that may contain useful information during the creation of a new article.

4.3 The recommender system as an automated search engine for AR contents

The core result of our research is the definition of an automated AR content generation process. This process is possible thanks to a correct definition of the interfaces between the different components of the system. To reach this task, the recommender system must be able to communicate with publishing system and BPaaS platform. The content generation process that we present is related to the described use case. As soon as an article has been generated by the publishing company, it is automatically added to the XML-based database of the publishing system. This database is accessible for the recommender system, in order to enable the implementation of the articles which need AR contents. Sending a request to the recommender it is possible to trigger an automated text analysis of the editorial content. This analysis enables the research of specific concepts in the text of the article, in order to detect the presence of editorial contents which may be useful for the automatic generation of AR contents. In this way, the recommender system works as a search engine. The concepts which the recommender is able to mine within the text of an editorial article are:

- *Addresses* (e.g., the address of a shop which may be described in an editorial article).
- *Dates* (e.g., the date of a concert which is the topic of an article and will take place in the future).
- *Email addresses* (e.g., the contact of the author of the editorial article).
- *Phone numbers* (e.g., the phone number of an association which is described in the article).
- *Websites/Social media* (e.g., the webpage of a theme which is treated in the editorial article).

These concepts are detected according to specific algorithms, which are based on the research of notions with comparable semantic relevance and they are derived from the presented ontological model. They are automatically extracted from the text of the editorial content in order to define relevant AR contents for the original article. From the presented items, it is possible to derive specific AR contents, which are useful to be integrated in the presented MR system through a completely automated process.

These possible AR contents are the following:

- AR link of a web mapping service, according to the extracted *address*.
- AR link of the function of the mobile device, which enables to save a *date* on the user's calendar.
- AR link of the email provider of the user to write an email to the extracted *email address*.
- AR link of the function of the mobile device, which enables to call a *phone number*.
- AR link of an internet browser, which enables to visualize the extracted *webpage*.

The described AR content generation process has a high degree of automation. The only human interventions that are needed are the upload of the editorial content and the final approval of the AR contents suggested by the recommender system.

5 Prototypical Implementation and Evaluation

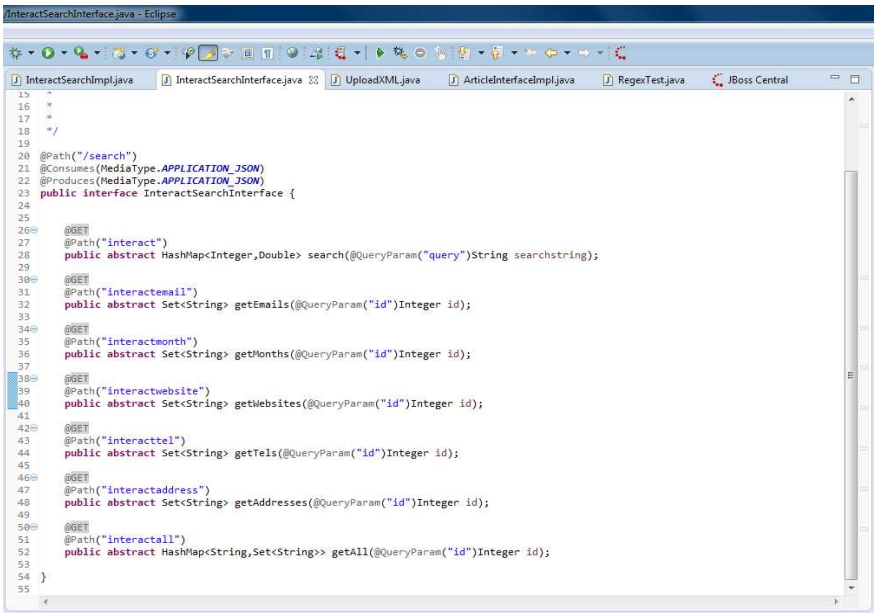

Fig. 4. Screenshot of the prototypical implementation.

We have created a prototypical implementation of the automated AR content generation system in order to demonstrate the implementability of the artifact and to

show our proof-of-concept. The prototype has been created through the platform Java EE.

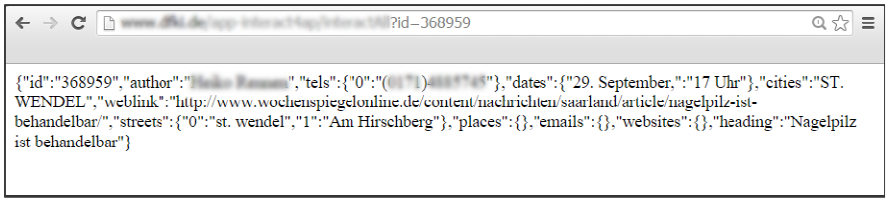

Fig. 5. The recommender system detects potential AR contents related to a specific editorial article in order to generate AR links.

The whole system is reachable on a server through a simple HTTP request/response scheme. It is possible to send requests to the server to interrogate the editorial content which constitutes the database. These requests trigger the automated search of defined contents in the text of an article. The process is completely automated and the request only has to be referred to a specific article-ID, which identifies a specific editorial content that has to be analyzed, in order to extract potential AR contents.

Fig. 6. Screenshot of the AR interface created according to detected AR contents.

According to a design-oriented methodology [3], the presented research must be evaluated against following evaluation criteria:

- *Validation of the quality of the recommendations*: validation of the relevance of the recommendations detected and proposed by the recommender system according to recall and precision [31].
- *Integration into the existing system*: evaluation of the integration of the automated AR app creation process into the existing publishing system, from the creation of the print contents to the creation of the AR app.
- *Reliability of the extracted AR contents*: validation of the relevance of the AR contents, which are automatically extracted from the text of the print medium.

6 Conclusion and Future Work

This paper shows a novel approach which integrates print media and internet-based contents, by means of the definition of hybrid media systems based on MR environments. The added value of the defined approach is expressed by the definition of an automated AR content creation process which is based on the direct analysis of the editorial content through the integration of a recommender system. The integration of a recommender system enables several goals: the readers can experience a novel and individualized reading approach and the publishers are able to provide a persistent modification of the editorial offer, thanks to the integration of an automated and industrialized AR content generation process. Our research designs a structured and persistent modification of the offer of contents for print media through the definition of a MR environment.
Several aspects have large potentialities in terms of research and permit further implementations. The text analysis of editorial contents may be further refined and also extended to different kinds of metadata regarding editorial contents. Moreover, the recommender system could also integrate thematic external search engines, in order to provide more specific results for the creation of AR contents. The presented concept offers interesting outlooks to define innovative applications able to integrate AR tools in print media and even in different fields. Our concept offers results which may be easily extended to various paper-based AR systems. Other domains that use print medium (e.g., learning, advertisement, marketing and communication, etc.) may take advantage of the presented research. In terms of research, it could certainly contribute to the definition of an advanced concept of hybrid media which could shape new business models based on the use of AR technology.

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