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A Model of Hybrid Media for Publishing Industry

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Abstract. Supported by the wide diffusion of mobile technologies, internet-based media risk to become a popular alternative to traditional print media. The ubiquitous connection to the internet enables to reach a multitude of virtual contents such as videos, images, 3d representations and hypertexts. Moreover internet-based media enable the direct interaction between user and publisher: the user can provide feedback, express preferences and receive related recommendations. Motivated by the necessity to modify the traditional paradigm of print media to face the competition of internet-based media, we show a perspective oriented to integrate paper medium and internet-based contents. This approach finds expression in the core results of our research: the ontology model of a general mixed reality (MR) environment for hybrid media, which is adopted to describe our system, and the integration of a recommender system into a MR environment, which is possible through the development of an automated app creation process.

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

1 Introduction

The development of a new generation of mobile devices with ubiquitous internet connection made possible the fast development of internet-based media and their diffusion on a wide scale. The growth of the modalities of web usage and the parallel increasing rate of internet users played an important role in the development of several internet-based services, like online newspapers and online classified advertisements platforms [1]. Therefore, since few years print media must face the competition of online press services and have to deal with a rapidly growing competitor [2].

The substantial difference between print media and internet-based media is their spatial extension. Print media are limited to the space of the medium that is the limited space of the layout of the publication. Internet-based media have instead the same extension of the internet, therefore they do not have spatial limits. This peculiar feature enables the presence of several types of contents, which are almost limitless in terms of quantity and almost limitless in terms of typology (e.g., videos, galleries of images, 3d representations, hyperlinks, etc.). Moreover, internet-based media can count on the advantage to permit the development of specific user oriented services.

Services such as recommender systems and user adaptive advertising give to the users the possibility to go through an individualized reading experience and to find easily relevant contents. This aspect offers a new perspective to the traditional business models of publishing companies because it enables to reach focused targets of consumers. Furthermore, the possibility to share contents on social media and to comment the editorial contents opens a direct connection between user and publisher, useful to deduce preferences of the consumers and to receive feedback.

Print media represent the traditional medium to access to editorial contents. One of the advantages of print media is that they are tangible and conservable goods and from the point of view of the business, print media refer to a structured existing market. Since decades or even centuries, millions of publishing houses in the world provide a huge quantity of different typologies of print media. It means that several targets of customers are already covered and, even if the number of internet-based media editors is increasing, the large market of print media must continue to be considered as a market with enormous potentialities.

In the field of battle where internet-based media and print media are almost unanimously presented as rivals, we want to sketch a novel and different perspective. In this paper we define a new paradigm oriented to interpret internet-based media and print media not anymore as antagonist players but rather as complementary entities. We define a *hybrid media* model [3], in the meaning of a third way between internet-based media and print media. The target of our research is to present an example which is able to merge together positive aspects of print based media and positive aspects of internet-based media, in order to draft new potential business models for the editorial field. This is technically possible through the definition of a mixed reality (MR) environment where innovative augmented reality (AR) tools [4] connect print medium and internet-based virtual contents. Therefore the definition of specific MR environments accessible through a mobile device may amplify the sphere of interest of print media and drastically change the editorial market [5].

The model of hybrid media that we present enables to integrate the content of an existing newspaper using mobile technology. Reading print based contents, the users are able to access to virtual contents just filming the print medium with an internet connected mobile device. We defined an AR app useful to bring the user into a mixed reality environment, where the border between print media and internet-based media blends in order to offer a new reading experience. Our concept shows that the infinite space of the internet is now available on a print medium. In order to cross a wider range of possibilities, useful to make our model more adaptable to different specific contexts, we defined three different scenarios: editorial articles (S1), advertisements (S2) and classified ads (S3). For every scenario, we applied the general classification of MR environment and we defined specific typologies of contents. Therefore, these contents may belong to the real environment, to the augmented reality environment or to the virtual reality (VR) environment. In this way it has been possible to categorize and propose specific tools and features useful to define a possible taxonomy of *hybrid contents*, in order to enable the creation of AR apps, according to specific needs and technical possibilities. A particularly innovative feature that we introduced in the outlined MR system is an integrated recommender system. The recommender system

provides relevant recommendations about editorial contents or user adaptive advertising. These recommendations are related and triggered by contents printed on the print medium but, since they belong to the defined MR environment, they can be expressed in form of AR or VR recommendations. Therefore we integrated typical tools of internet-based media into print media by means of the creation of a MR environment. The introduction of this kind of tools implies a high rate of individualization of the final product. In this way, we defined not only an innovative application but an automated process to create it, in order to offer a large added value.

The methodology is oriented to identify specific scenarios in order to design solutions useful to improve the originally inherited situations. Among other research purposes, the defined mixed reality environment will be the ground where we validate tools coming from different contexts, such as the individualized recommender system.

The contributions of the paper can be summarized as follows:

- Introduction of our concept and motivation of the need to consider the complementarity of internet-based media and print media in order to define a *third way*, useful to stop the decrease of popularity of print media. The alternative we introduce is a new business model based on hybrid media which is built combining positive aspects of both internet-based media and print media, through the creation of a MR environment.
- Brief exploration of the status quo. We introduce examples of integration of AR tools in print media and we present some of the possible technical modalities of detection for the introduction of virtual contents in the real environment with mobile devices.
- Presentation of the model of hybrid media we developed. We introduce the ontology of the derived MR environment in order to describe the knowledge framework of the hybrid media model we are presenting and we introduce the different scenarios that we analyzed.
- Description of the implementation design. We describe the system architecture oriented to the creation of an AR app which is based on our concept and integrates an individualized recommender system. The interfaces which are necessary to integrate internet-based tools into the system (such as the mentioned recommender system) are then introduced.
- The paper concludes with the synthesis of the achieved results, a short outlook and a discussion of future work.

2 Related Work

One of the first examples of integration of AR markers in a print medium is represented by the "MagicBook" [6]. 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" [7] created one of the first AR apps which integrates 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 [8] and similar experiences have been performed by other editorial companies (e.g., "Stern" [9], "Auto Bild" [10], "Welt der Wunder" [11], "Rheinische Post" [12], etc.).

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 [13], Vuforia AR SDK [14], Wikitude SDK [15], 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 [16]. Moreover, innovative techniques such as OCR-tools [17], encoded paper [18] or text patch recognition [19] may be involved to create AR systems.

Even if the possibilities offered by hybrid media are not confined only in the domain of augmented reality [20], 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 [21]. However, the integration of virtual and real environments is a complex issue. In particular, 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 [22]. 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 updated AR app, which is realizable only through a structured and automated app creation process. The creation of a release of a magazine that uses AR tools is far away from the definition of a structured hybrid media system which integrates paper medium and internet-based contents. Therefore we identified the need to define an automated AR app creation process in order to enable the possibility to create an AR app, which is automatically updated to the latest release of the print media. Furthermore, through the analysis of the related work, we realized that the typology of contents is usually limited to virtual contents such as 3D models, images or animations that are directly superimposed on the print medium, as if the great opportunity to reach links on the wide space of the internet were generally not considered. In this background, the interesting result that our research offers is the integration of an individualized recommender system, which represents a new and original typology of virtual content for

hybrid media. The definition of a domain ontology is necessary to define the knowledge model of the system, in order to shape the possible innovative contents, which can be integrated into a general MR environment for print media. In this context, the idea to define a wide and structured MR environment useful to take advantage of the opportunities offered by internet-based media represents a challenge and an innovative approach to define new business models for the editorial field.

3 Functional Design

The concept we want to state is expressed drafting a general model of hybrid media. This model offers a direct connection between print media and internet-based media and the target is to assume it as a general basis to derivate specific hybrid media applications. The system we propose generates a MR environment, where an AR app for mobile devices works as an interface between the real and the virtual environment. The ontology of the derived MR environment is presented in order to describe the knowledge framework of the model of hybrid media we defined and to express peculiarities and conceptual design of the presented paradigm.

To demonstrate the possibility to adapt the concept that we propose in different contexts, we defined three different scenarios according to different editorial and virtual contents. The available contents are classified depending on the typology of environment where they are visualized. Print based editorial contents are printed elements and they lie obviously on the print medium. They contain trigger entities which are printed elements as well. Therefore print based editorial contents lie in the real environment, they can be touched directly by the user and they can be shown through the camera of the device. AR links are virtual elements and they are superimposed on the print based editorial contents. They may be visualized only on the screen of the device and their presence on the print medium defines an AR environment. Recommendations and browser based virtual contents are defined in a virtual reality environment since they are detectable in a space populated by only digital entities. Virtual contents may be opened through AR links and they can lie in both AR and VR environments. Browser based virtual contents define effectively a VR environment, whereas virtual contents visualized on the print based editorial contents (AR contents) define an AR environment. The integration with a recommender system represents a specific added value of the described model. Furthermore, recommendations may be represented not only as virtual contents but also in form of augmented reality entities. As soon as a user starts the application, information about user's profile and preferences are detected and querying the recommender system, the AR app receives a list of contents which are present on the specific release of the paper based newspaper and are considered relevant by the recommender system for the specific user. Relevant editorial contents are highlighted with an AR graphical representation, so the user can receive relevant AR recommendations directly related with the print medium.

The knowledge model of the system has been shaped according to the definition of Reality–Virtuality Continuum [4] and it represents a concrete application of this theoretical definition. The proposed scenarios have been derived from the knowledge

model and they represent a synthesis of the requirements of the system. The development approach has been led according to the following methodological process [23]:

- Determination of the domain and scope of the ontology through the definition of specific competency questions [24].
- Enumeration of important terms in the ontological domain through a brainstorming process.
- Definition of classes and class hierarchy through a *top-down* development approach [25].
- 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).

3.1 Data Model (Ontology)

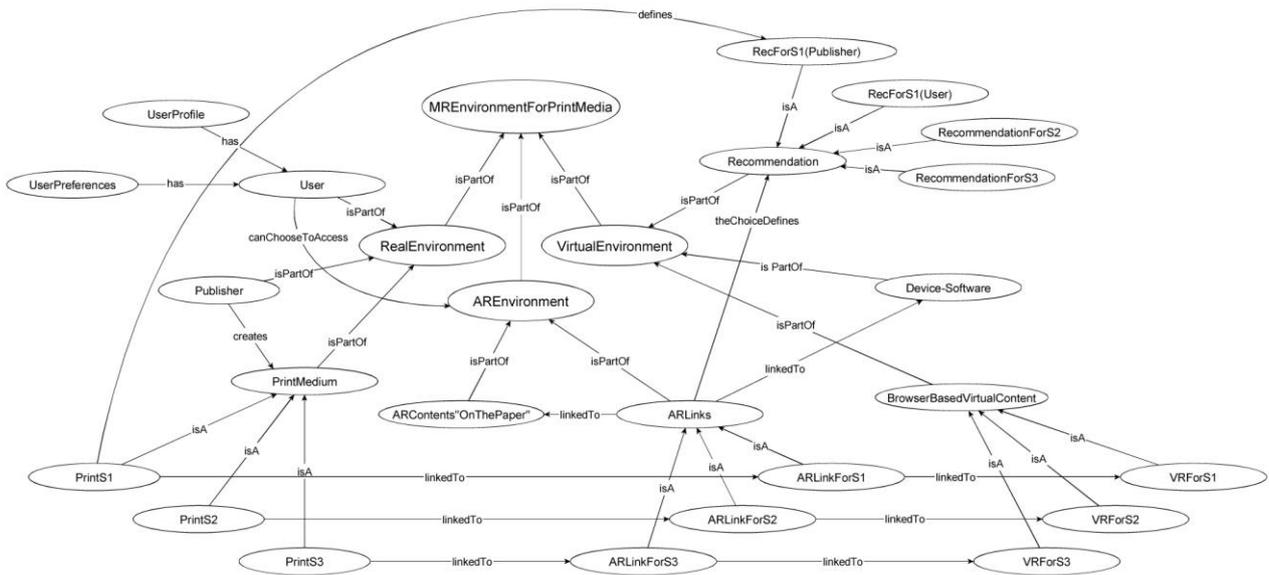


Fig. 1. Domain ontology.

The knowledge model which defines our concept is expressed by the domain ontology presented in Fig. 1. The creation of a model of hybrid media 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 ob-

jects [26]. The definition of a MR environment is the necessary condition to permit the creation of an AR interface for hybrid media. The model of hybrid media that we present in this paper 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 and different users who read the print medium and have peculiar preferences and profiles. 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 enable the connection between print based contents and virtual entities. Clicking specific AR links, the users can access different virtual contents. Hence, it will be defined a new paradigm to access the content of print media. Several typologies of contents may be included in this hybrid environment: galleries of photos, hyperlinks, videos but also individualized services like virtual recommendations.

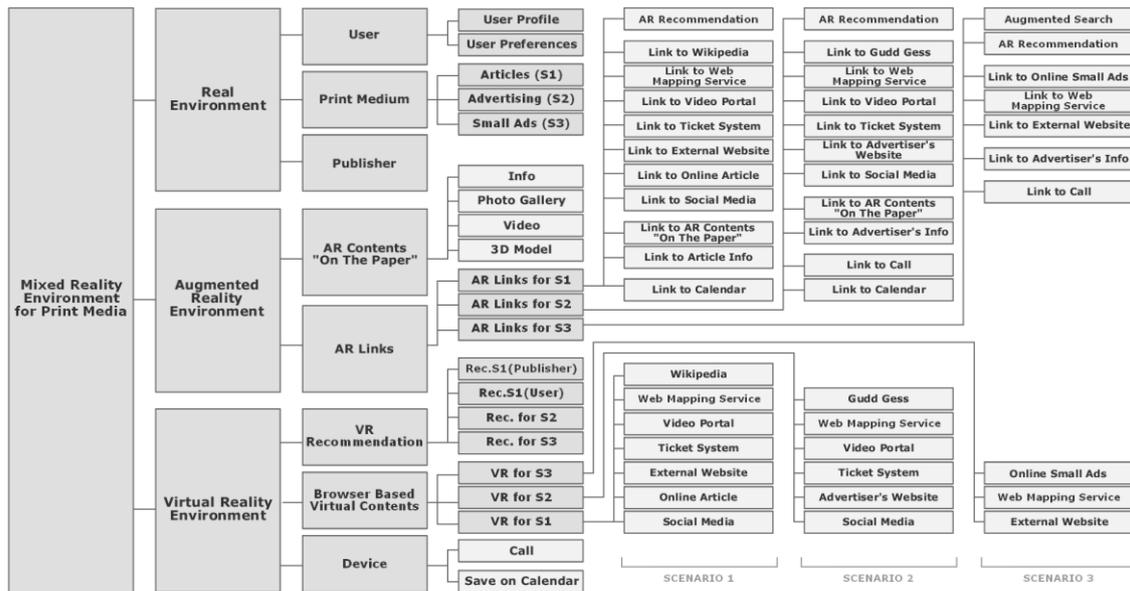


Fig. 2. Hierarchical representation of the ontology and differentiation of the content for every different scenario.

The three different scenarios represent typical editorial contents for print media. They are editorial articles (S1), advertisements (S2) and classified ads (S3) and they are chosen in order to cover different possible editorial field and contents. Every typology has a print based component which is the trigger entity useful to access specific AR links in an AR environment as soon as 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.



Fig. 3. Simulation of the AR app interface.

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 [27]. 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.

3.2 Scenario 1

In our concept, the scenario 1 (S1) refers to the contents of the MR environment related to 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: in Fig. 2 it is possible to have an overview of these links for every scenario. AR links related to S1 are divided into three 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. A specific part of the layout of

the interface is effectively dedicated to permanently host recommendations (Fig. 3). 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 third category of AR links related to S1 is represented by AR links which open AR contents. Opening these kinds of links, the user is able to superimpose on the print medium new virtual objects. Therefore, these kinds of links do not trigger a virtual reality environment (for example a browser) but they modify the existing AR environment. These accessible contents are virtual entities (e.g., 3D models, photo galleries, etc.) which are soldered on the print medium and can be explored moving the print medium itself, remaining in an AR environment. They are detectable simply using an AR interface and they have physical presence on the print medium, therefore we defined these entities AR contents "on the paper".

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. Moreover, the S1 presents the peculiarity to provide recommendations not only to users but also to actors of the publishing company. In this scenario, 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.

3.3 Scenario 2

The scenario 2 (S2) refers to the contents of the MR environment related to print based advertisements available on the print medium. AR technologies offer interesting opportunities in the field of marketing and advertising. New expressive modalities are possible through the integration of virtual contents and tangible objects like the images of a print medium. Scanning an advertisement with the smartphone, the user is able to access the MR environment defined by the AR interface. Similarly to S1, S2 presents three typologies of available AR links (Fig. 2). Every AR link is superimposed on the advertisement and enables the access to specific virtual contents.

The first category of AR links permits to visualize browser based virtual contents which are useful to enhance the communication of the message expressed by the advertisement (e.g., link to websites related to the advertiser, etc.). The second category of AR links related to S2 enables the connection to specific functions of the mobile device. Clicking on the specific superimposed AR link, the user has the possibility to call the closest shop promoted by the advertisement with her/his own smartphone. In case the advertisement promotes events with a specific appointment (such as a theatrical representation) the user can save the date on her/his calendar through this kind of AR link. The third category of AR links represents the most interesting typology of virtual contents available for S2: AR links able to open AR contents. This kind of link permits to show virtual contents directly on the print medium in a context of AR envi-

ronment. If a user accesses this kind of AR links, s/he will have the opportunity to experience interactive advertising campaigns where virtual objects (e.g., videos, 3D models, etc.) interact with the print based advertisement and the user as well. This opportunity makes possible to develop new commercial languages useful to express commercial contents with a higher rate of effectiveness. In the same time, the users receive a wider quantity of information about the advertisement.

The expression of the interest of a user in a promoted item is learnt by the integrated recommender system in order to provide specific recommendations about similar related advertisements which meet the user's interest. In this way, every user is able to undertake her/his personal reading experience through the described individualized AR interface.

3.4 Scenario 3

The scenario 3 (S3) refers to the contents of the MR environment related to classified ads. The market of classified ads magazines suffered a hard time after the diffusion of analogous internet-based services. For this reason, the creation of an AR interface useful to integrate virtual contents and functions typical of internet-based services with print media offers new modality of access to these editorial contents. Similarly to S1 and S2, S3 presents three different typologies of available AR links (Fig. 2).

Scanning the classified ads with the camera of the smartphone, the user is able to access the described mixed reality environment. AR links related to the filmed classified ad are superimposed in the AR environment generated by the AR app. The user can access browser based virtual contents to integrate the information expressed in the text of the classified ad (e.g., link to a web mapping service useful to reach the advertiser, link to external websites to receive deeper technical information about the offered good, etc.). AR contents containing an overview of the classified ad, further information and contact of the advertiser can be expressed directly on the print medium. This makes easier the possibility to use specific functions of the mobile device. For instance, the user can easily call the advertiser through the defined AR interface. A particular added value of the described model is the possibility to conduct specific researches of contents related to the scenario 3 and represented via augmented reality directly on the text of the print medium. The user who is looking for specific objects in the section of the print medium related to the classified ads has the possibility to look for specific terms in a search field. This "augmented search" gives back to the user AR representations useful to highlight contents which satisfy the request of the user directly on the print medium.

Every interaction of the user manifests her/his interest in specific kinds of ads. Hence, the recommender system provides appropriate recommendations about similar ads which result interesting for the user, according to her/his preferences and profile. The use of the defined AR interface to experience a virtual enhancement of classified ads in print media enables the possibilities to directly compare different analogous ads and to offer an individualized reading experience to the users. Moreover, the integration of virtual contents in the text of the classified ads permits to amplify the strength of the communication due to the access into the described mixed reality environment.

4 Implementation Design

We tested our concept developing a specific model of hybrid media tailored on the needs of an existing publishing company, in order to consider the validity of the defined paradigm. We define the necessary components of the system and we summarize our considerations through the definition of the interfaces.

4.1 Architecture of the System

The core building blocks of the system are expressed by the following components: publishing system, recommender system, external services, BPaaS platform, AR app.

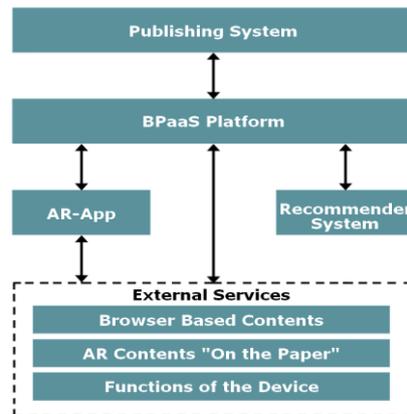


Fig. 4. Architecture of the system.

Publishing system. We tested 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 summarized 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.

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. In order to provide precise suggestions, it is necessary to receive (or to extract with text mining techniques) specific information

from related editorial contents. Therefore the information archived in the publishing system must be analyzed and translated into an ontological language in order to be elaborated by the recommender system. Different typologies of suggestions are provided for different typologies of contents.

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.

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.

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 print 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.

4.2 Interfaces between the Components.

The interface between publishing system and AR app permits the data exchange and the update of the existing editorial contents. The editorial contents are sorted by typology, according to the presented classified scenarios. The choice of virtual contents and the definition of the relation between trigger entities and virtual contents permits the creation of an AR app related to a specific release of the newspaper. This process is automated in order to satisfy the requirement of industrialization of the publishing industry. The multitude of potential virtual contents which can be included in the AR app is defined in the hierarchical representation of the domain ontology (Fig. 2).

Particularly interesting is the interface between AR app and recommender system. The integration of a recommender system permits the direct connection between the editorial contents (which are printed on the print medium) and thematic related virtual contents (which are available on the internet). The presence of a recommender system makes possible the profiling of the users, in order to understand their preferences. This aspect is an added value for the users, who receives an individualized service, and for the publishing company as well. It represents a huge opportunity for print

media to understand the preferences of consumers which is useful to receive a feedback about the offered editorial content. This fact may be useful, for instance, to modify the editorial line of the newspaper according to the preferences of the majority of the consumers or to show oriented advertisements with a higher probability to reach the right targets. Interesting aspect is the possibility to provide recommendations in form of AR entities to offer suggestions about printed editorial contents. Querying the recommender system, the AR app receives a list of contents which are present on the specific release of the paper based newspaper and are considered relevant by the recommender system for the specific user. In this way it is possible to highlight with AR graphical representations the relevant print based contents which are recommended to the user. These recommendations lie in the AR environment and therefore directly on the print medium. Furthermore, the publishing system receives recommendations about editorial contents which are going to be published, in order to provide suggestions to the journalists during the phase of creation of editorial contents. Through the defined "augmented search", the user can ask to the AR app if a content is present on the print based release of the newspaper, just through a search field. In case the recommender system finds relevant results, they will be represented directly on the print medium, by means of the possibility to access an AR environment.

5 Conclusion and Future Work

This paper has shown a novel concept which permits to reduce the distance between internet-based media and print media, opening new perspectives. The expressed concept is not merely an application of augmented reality in the editorial field but it defines a novel possibility to integrate complex instruments such as a recommender system with traditional print media. This happens using mobile technology to define a mixed reality environment in which real environment, augmented reality and virtual reality coexist in order to enhance the reading experience of the user.

Through the use of the AR interface the reader is not anymore a passive user but rather s/he becomes an essential part and active actor of the defined MR environment. The user has the possibility to choose her/his contents and to express her/his preferences. The added value of our research project is the definition of a specific mixed reality environment where the user may easily experience a novel and individualized reading approach, by means of the integration of a recommender system.

Our research project designs a structured and persistent modification of the offer of contents for print media through the definition of a MR environment. It is not just a sporadic integration of AR tools in print media but it is designed to be the result of a persistent app creation process which is defined according to the shown classification of virtual contents. Several aspects have large potentialities in terms of research and permit further implementations. The definition of a general model applicable to different contexts makes wider the range of possible develop of our research.

First empirical evaluations have shown that the system ensures a higher rate of engagement and participation of the user. A complete evaluation of the created artifact is in progress and it will be subject of future work. According to a design-oriented

methodology [28], the presented research has to be evaluated against following evaluation criteria in future work:

- *Usability of the system*: the system will be validated according to ISO 9241-10 & 9241-11.
- *Validation of the quality of the recommendations*: validation of the relevance of the proposed recommendations according to recall and precision [29].
- *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.

The evaluation will be led according to following methods:

- *Qualitative evaluation*: interviews of focus groups about specific features of the described system (AR app and AR app generation process).
- *Quantitative evaluation*: usability tests with users in order to test specific features of the AR app.

The presented concept offers interesting outlooks 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 and every domain that uses 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 print media useful to shape new business models based on the use of AR technology.

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