



HAL
open science

Proposition of an intelligent system based on the augmented reality for warehouse logistics

Safa Gharbi, Hayfa Zgaya, Nesrine Zoghلامي, Slim Hammadi, Cyril de Barbarin, Laurent Vinatier, Christiane Coupier

► To cite this version:

Safa Gharbi, Hayfa Zgaya, Nesrine Zoghلامي, Slim Hammadi, Cyril de Barbarin, et al.. Proposition of an intelligent system based on the augmented reality for warehouse logistics. 16th International Conference on Logistics and Maritime Systems (ICLMS 2014), Nov 2014, Dubai, United Arab Emirates. hal-01718277

HAL Id: hal-01718277

<https://hal.science/hal-01718277v1>

Submitted on 27 Feb 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Proposition of an intelligent system based on the augmented reality for warehouse logistics

Safa Gharbi, Hayfa Zgaya, Nesrine Zoghliami, Slim Hammadi

Cyril De Barbarin, Laurent Vinatier, Christiane Coupier

Abstract—Increasing productivity and quality of service, improving the working comfort and ensuring the efficiency of all processes are important challenges for every warehouse. The order picking is recognized to be the most important and costly activity of all the process in warehouses.

This paper presents a new approach using Augmented Reality (AR) in the field of logistics. It aims to create a Head-Up Display (HUD) interface with a Warehouse Management System (WMS), using AR glasses. Integrating AR technology allows the optimization of order picking by reducing time of picking process, increasing the efficiency and delivering quickly. The picker will be able to access immediately to all the information needed for his tasks. All the information is displayed when needed in the field of vision (FOV) of the operator, without any action requested from him.

These research works are part of the industrial project RASL (Réalité Augmentée au Service de la Logistique) which gathers two major partners: the LAGIS (Laboratory of Automatics, Computer Engineering and Signal Processing in Lille-France) and Genrix Group, European leader in warehouses logistics, who provided his software for implementation, and his logistics expertise.

Keywords—Augmented Reality (AR), logistics and optimization, Warehouse Management System (WMS), Head-Up Display (HUD).

I. INTRODUCTION

Logistics means having the right thing, at the right place, at the right time in personable way". Logistics is a very broad area. It can be understood through three distinct business groups: industrial logistics, warehouse logistics and distribution logistics. For our research, we are working on the logistics of distribution. Indeed, a warehouse is a commercial building for buffering and storage facility that receives goods and products for eventual distribution to consumers or other businesses [1][2].

In order picking process, workers collect sets of items from an assortment in a warehouse according to a work order. Then, they deliver them to the next station in a precisely designed material flow process [3]. Experiences from practice show that

about a half of the total operating expenses of a warehouse is spent by order picking [4]. This is caused by the complexity and the labor intensity of order picking processes [5].

The possible improvements in warehouse logistics rest a lot upon new technologies, and especially, upon how the operators have access to picking instructions. These instructions, the arrangements and the attribution of the commands are generated by the Warehouse Management System (WMS). Different techniques exist to support the order picking in warehouses: the first technique that appeared, and the most simple, is the pick-by-paper which consists on printing the directions and the quantity to pick on a paper and giving it to the operator. But this technology has low productivity because it does not allow the user to have both hands free. To overcome this loss of productivity, new technologies have been developed such as the pick-by-light in which lights point out the location of the picking. But it has disadvantages because it deprives the operator of having both hands free and creates difficulties if several operators are working in the same part of the warehouse.

The most widely used technology these days is the pick-by-voice, launched in the end of the 1990's, it is now almost the only technology used in big warehouses [6]. The picker wears a headphone connected to a device which receives vocally the instructions from the WMS. This system is now proven efficient, but is still far from perfection[7]. First of all, the picker lacks of visibility on its command, when an experienced worker could organize his mission with the paper list, to pick first the sizeable packages. Now, he has to follow exactly the order given by the WMS. Secondly, the operator cannot choose when he accesses to information, and the synthetic voice turns out to be irritating after a day of work. In addition, the pick by voice is difficult to use in noisy environments.

The purpose of this paper is to adapt the technology of Augmented Reality (AR) to modern logistics in order to enhance the pickers' comfort.

The main task of the project is to design a system using AR. A Head-up display (HUD) interface allows the operator to consult every needed information, and only when needed. AR glasses made this type of interface possible for an operator while keeping his hands totally free. This device with an embedded camera will also enhance the capacity to locate the picker (refer to 4.1 Localization check). This paper is structured as follows: Section 2 describes the problematic of AR RASL project. Section 3 details research background related to AR. Section 4 and 5 present respectively the scientific approach and the system architecture. The prototype is described in section 6. Section 7 presents a discussion of the results. Finally, section 8 presents some conclusion and prospects.

Safa Gharbi is at the Ecole Centrale de Lille, LAGIS-UMR CNRS 8219, Cité Scientifique- BP 48- 59651 Villeneuve d'Ascq CEDEX (phone: 33 (0)3 20 67 60 70; fax: 33 (0)3 20 33 54 18; e-mail: safa.gharbi@ec-lille.fr).

Hayfa Zgaya is at the University of Lille 2 (phone: 03 20 62 37 42; e-mail: hayfa.zgaya@univ-lille2.fr).

Nesrine Zoghliami is at the Ecole Centrale de Lille (e-mail: nesrine.zoghliami@gmail.com).

Slim Hammadi is at the Ecole Centrale de Lille (e-mail: slim.hammadi@ec-lille.fr).

Cyril De Barbarin is at Generix Group (e-mail: cdebarbarin@generixgroup.fr).

Laurent Vinatier is at Generix Group (e-mail: ccoupier@generixgroup.fr).

Christiane Coupier is at Generix Group (e-mail: ccoupier@generixgroup.com).

II. INDUSTRIAL PROBLEMATIC OF RASL PROJECT

Generix Group is a vendor of collaborative software for the retail ecosystem. We work closely with Generix Group which advice and counsel have proven useful in every step of the project especially when it came to understand the current state of logistics. They had successfully conducted a similar project a few years ago to bring the pick by voice in the warehouses. Their vision as an industrial in the field of logistics is interesting and it raises several questions for the future of the project. One of the main tasks of this project is to be able to limit the operator's errors during the picking process. The RASL system has to be able to determine if the picker is standing in front of the right item in the right aisle.

The WMS is used to control the movement and storage of goods within a warehouse [8]. It sends the orders to the picker by vocal. The WMS sends these orders without any optimization. Each operator receives the mission and prepares it respecting the order given by the WMS. So, because of traveling unnecessary kilometers, he lost a lot of time preparing the order. In previous work [9], we proposed an alliance between multi-agent system and optimization. We developed an algorithm able to affect the order to the nearest picker and assign to it the shortest path for picking mission. In order to enhance the operators work and optimize more their path, we propose to integrate the AR technology in the picking process to guide them in the warehouse. The optimization is based on the using of the pick-by-AR and the optimization algorithm [9].

III. STATE OF THE ART

The AR technology has been successfully implemented over the past two decades in military and scientific projects. Research activity in the field of AR has been recently increased significantly thanks to the emergence of Smartphone and Mobile AR [10]. This technology consists on mixing the real and the virtual worlds in order to provide the user with digital information to guide and help him to understand his environment.

Some researchers define AR as a way that requires the use of Head-Mounted Displays (HMDs). To avoid limiting AR to specific technologies, this study defines AR as systems that have the following three characteristics[11]:

- 1) combines real and virtual
- 2) Interactive in real time
- 3) Registered in 3-D

The first attempt to AR is referred to Ivan Sutherland, in 1965 [12], who published "The Ultimate Display"[13]. In 1968, he built a head-mounted computer graphics display that also tracked the position of the user's head movements.

AR technology can be used in several kinds of problems. The most successful AR applications concern the field of medicine care [14], [15], entertainment [16], art [10], education and learning [17], manufacturing [18], [19], aeronautical maintenance [20].

The use of AR becomes increasingly popular in many ways following statistics made by Hidden Inc (see figure 1).

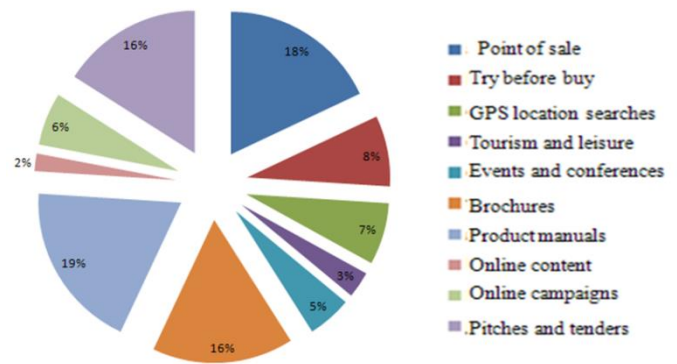


Figure 1. AR use statistics

Inc. [21] summarized that there were already 83 augmented reality applications in the App store in 2008. Today each month 35 new AR applications are launched and 43% of total applications are for free [1].

A group of German researchers made several studies on the application of AR in logistics in 2008. The main purpose of these studies was to demonstrate the efficiency of the AR for the picking process compared to other techniques. They focused on the determination of the path display type which minimizes the error rate (between an arrow, a framework and a virtual tunnel) [22]. However, the proposed solutions used in these studies are not applicable in a warehouse because they require the installation of two cameras by aisle, a huge investment for a full warehouse.

An Austrian company specialized in logistics, Knapp[23], conducted a similar project involving augmented reality in warehouses in 2011. But, after passing the test phase a few years ago, this project has provided over its progress and seems to have been put on standby.

Lithuanian researchers [1] have also worked on the use of AR technology in the field of logistics in 2013 in order to decrease error rate of object selection and decision-making time. But they presented an idea without developing an AR pilot product for logistics which is delayed by a lack of hardware equipment for real time tracking of people on a warehouse environment.

Actually, the most used technique is the pick by voice. The operator receives and executes the order received from the WMS by voice[24]. The picker comfort is necessary to satisfy customer orders and deliver in time. Despite the increased use in various fields, the AR technology still unused in the field of logistics and particularly in warehouses. Thanks to our collaboration with an industrial partner, we are integrating the technique of pick-by-AR which represents an innovation in warehouses and especially for order picker who still working with recognition voice technique. We propose an intelligent system using the AR glasses to guide operators. Our goal is to enable them to work hands free and also reduce the error rate and travel fewer miles during the picking process using our optimization algorithm.

IV. LOCALIZATION CHECK AND MARKER BASED AUGMENTED REALITY

With maker-based AR systems, markers are positioned at specific locations on material elements for which we want to add virtual images, also called augmentations.

At first, we tried to have a localization of the operator in real time. Items in the warehouse will be equipped by markers to identify them. A marker is a simple pattern on a white background surrounded by a black frame. The algorithm represented by the figure 2¹ [25] must first detect and identify the marker, then deduce real-time position and orientation relative to the camera.

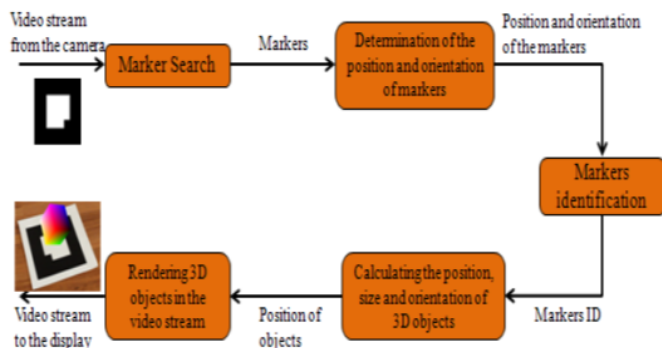


Figure 2. Principle of operation of detection algorithm

Each item is represented by a marker. When it is in the FOV of the picker, it is automatically read by the embedded camera and analyzed by the device, which will be able to tell the operator if this marker corresponds to its destination, and otherwise, tell him where to go in the aisle (or to change of aisle if needed).

We studied different techniques such as the smart floor, the recognition form and the QR Code. This later doesn't require a huge installation. It just needs to stick it on each shelf. We choose the QR Code technology for its several advantages such as high capacity, small space, fast reading.

QR Code, which stands to Quick Response Code, was created in 1994 by Denso Wave Corporation in Japan. It has been approved as an AIM (Anviz Intelligent Management) Standard, a JIS Standard and an ISO standard [26]. This two-dimensional bar code is used in a wide variety of applications, such as manufacturing, logistics, and sales applications [27]. A QR Code can store much more information than a one-dimensional bar code which contains data in one direction only whereas a QR Code contains information in both the vertical and horizontal directions [28]. It can hold a considerably greater volume of information: 7.089 characters for numeric only, 4.296 characters for alphanumeric data, 2.953 bytes of binary (8 bits) and 1.817 characters of Japanese Kanji/Kana symbols.

The QR Code has a function of an error correction. Four levels of precision exist, allowing the correction of the errors [28]:

- L Level: about 7 % or less error can be corrected.
- M Level: about 15 % or less error can be corrected.
- Q Level: about 25 % or less error can be corrected.
- H Level: about 30 % or less error can be corrected.

The following figure² explains how to recognize the error level on a QR Code.

This means that H Level QR Code can be read, even if 30% of the code is unreadable. It is easy to adapt the type of QR Code used depending on the reading conditions (brightness, dirtiness etc.). So we can read it even if it is partly damaged or dirty.

V. THE SYSTEM ARCHITECTURE

A. Interfacing WMS-RASL

Once the operator is ready to react in function of information gathered thanks to the marker in his FOV, RASL interact with the WMS in charge of the whole picking process (Figure 3).

The WMS sends all the information needed for the picking process: the index for the order, the address of all its items (aisle, number, level), the quantity to pick, etc.

The operator identifies himself to RASL (log-on) with his personal card, and makes a picking request. The WMS, through RASL receives the information. If the log-on information is correct, it can generate the complete picking order such as described earlier. When the operator accepts the picking order, a signal is sent to the WMS through our system and the operator will be followed step by step by the WMS.

During the process, the WMS is notified each time an item is picked up until the order is complete. When it is done, the operator can log off, if he does not, another assignment is automatically generated.

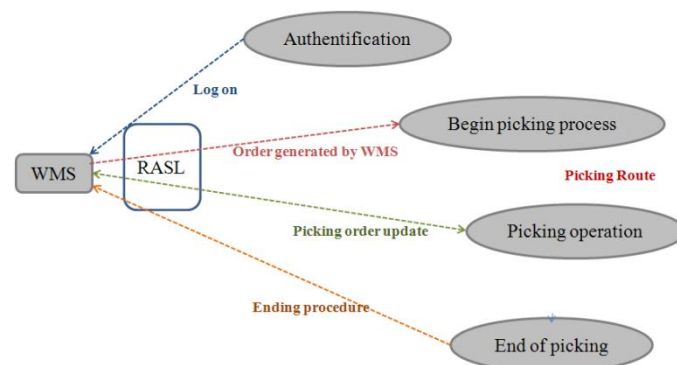


Figure 3. WMS interaction during the picking process

From a technical point of view, RASL has a central server monitoring the picking process and communicating with the WMS. The connection between the WMS' server and the RASL server is made through a Virtual Private Network (VPN). The communication itself is made through the Data Queue system used by MQ Series (Figure 4) [29].

¹ creativeapplications.net/processing/augmented-reality-with-processing-tutorial-processing

² QRStuff.com

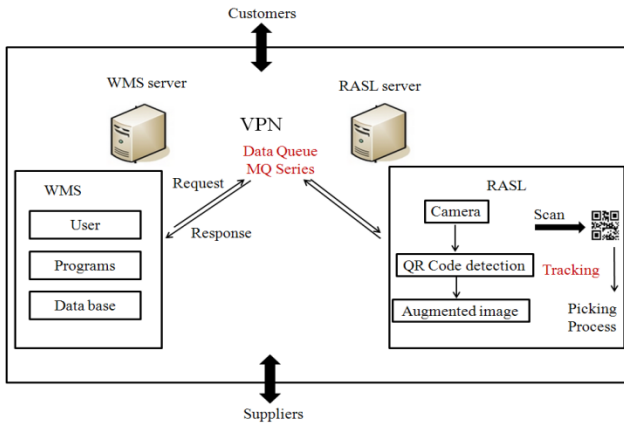


Figure 4. WMS and RASL communication

B. User interface

The AR glasses can display information in the FOV of the picker, dynamically without any input. The quality of the displayed information can then be greatly increased, in speed and in relevance as it matches the user's environment. However, the quantity and the display mode must be carefully and thoroughly thought. The interface has to display information that can be understood immediately. So, the choice of the symbols, colors, locations most adapted to each user especially when dealing with repeating tasks is very important. In order to customize the interface, the proposed system allow to the picker to choose his degree of expertise between a beginner, an intermediate and an expert. Such choice will not affect the quantity of information but the mode of display, with more information for a beginner (aisle X, number Y, level Z) or only with coordinate for an expert (X, Y, Z).

C. System components interaction

The RASL program is developed on OGRE (Object-Oriented Graphics Rendering Engine). Ogre is a scene-oriented, real-time, flexible 3D rendering engine³. The SDK of Laster Technologies⁴ proposes the following architecture (figure 5).

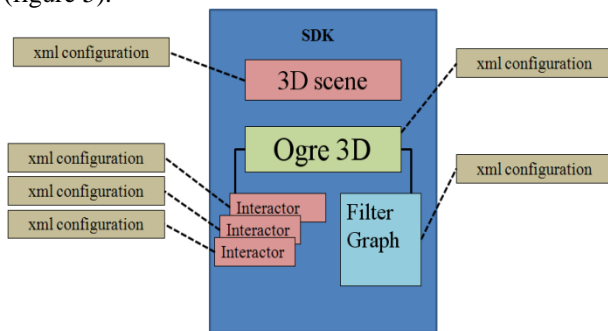


Figure 5. The functioning of the SDK of Laster Technologies

Figure 6 below represents a sequence diagram which is a graphical representation of interactions between the actors and

the system in chronological order in the Unified Modeling Language (UML).

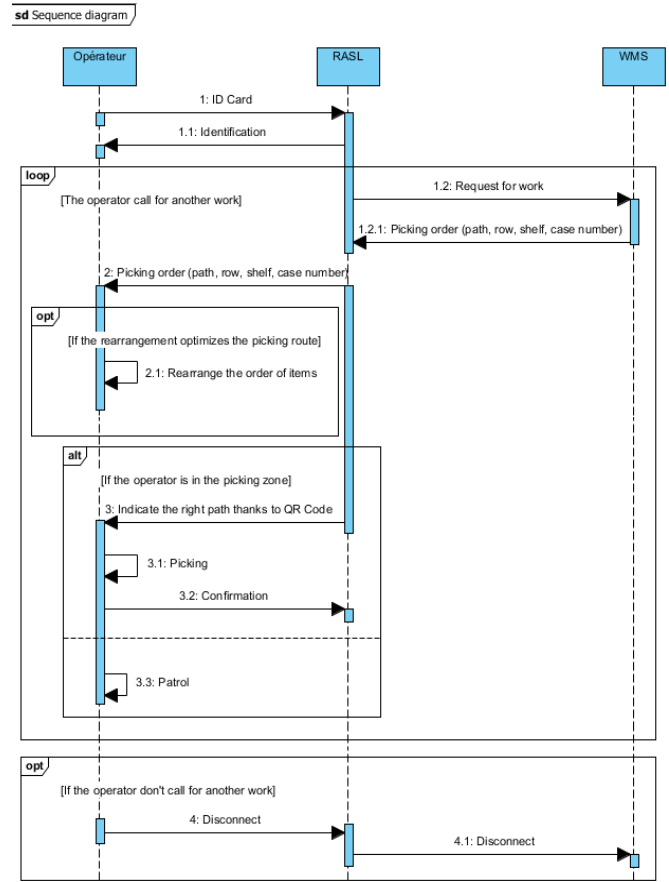


Figure 6. Sequence diagram

As mentioned earlier, one of the purposes of the RASL system is to enhance the pick-by-voice system which causes discomfort of the pickers by proposing an intelligent system based on the AR technology which is able to fill these gaps. Therefore, we describe hereafter the new pick-by-AR process.

VI. THE PROTOTYPE

A. Identification

The picking process can only begin if the pickers are available and ready to receive an order.

Each picker begins by identifying himself by presenting a personal identification card which is marker containing useful information about the picker (such as his name, his expertise and his director eye).

This step is represented in figure 7.

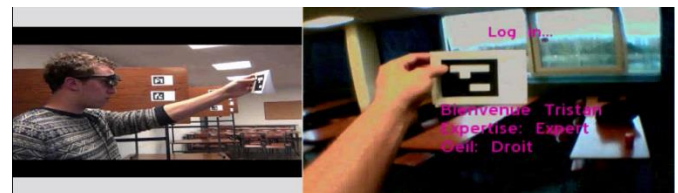


Figure 7. RASL ID card

³ orge3d.fr

⁴ laster.fr

B. Picking mission

After the identification, a request for a work is sent to the WMS. Each item is identified by an address, a code, a designation and a status. The answer issued by the WMS is the picking order which contains the list of all the items with their coordinates to find them (Aisle, number, level). As soon as this step is complete, the picker can begin his picking's mission, following the instruction of both WMS/RASL. The item's address is permanently displayed during the process. When the operator approaches the picking zone, the system indicates through the markers if he is on the right shelf, in the right path, in front of the sought item. As soon as the operator finds the right item, he can pick the items. The picking process is represented by the figures 8, 9.



Figure 8. Guiding the operator [30]



Figure 9. Right location

After he found the right location, the picker starts the picking/putting process (figure 10).



Figure 10. Putting phase

At the end of the picking mission, the picker can choose between asking for another mission or disconnect.

VII. DISCUSSION

The alliance between the AR technology in the warehouses and the optimization approach [9] allows to the operator to travel fewer miles. By assigning the nearest picker to the order and controlling items order, pickers earn approximately in terms of kilometers 11% and the gain can reach 28%. Reducing distance travelled by order picking and time of order picking enhance warehouse performance.

Order picking takes less time using AR. The information is displayed in the FOV of the operator so that it executes the command while keeping his hands free. The integration of augmented reality allows the gain in terms of time and productivity.

The alliance of the AR technology with the optimization algorithm

VIII. CONCLUSION AND PROSPECTS

Moving from the pick-by-voice to the pick-by-AR allows to the operators to have their hands free for the picking mission in order to provide better working conditions for them.

This project is the revolution which warehouse logistics are waiting for since 1990's. The facility and ease of access to essential information, as well as its clarity, are greatly improved, especially in noisy environments.

The device offers original features such as e-learning (the automatic training of novice users), and the possibility for experimented operators to sort the order of the picking in order to improve the preparation of his pallets. In the future, we aim to add more features to our system. The management of the missing after picking process is also an important task in warehouses that we intend to develop.

ACKNOWLEDGMENT

Our special thanks are extended to Ms Coupier, Mr De Barbarin and Mr Vinatier from Generix Group for their essential knowledge concerning the logistics warehouses and for the free access to Generix's WMS.

REFERENCES

- [1] A. Cirulis and E. Ginters, "Augmented Reality in Logistics," *ICTE Reg. Dev. Dec. 2013 Valmiera Latv.*, vol. 26, no. 0, pp. 14–20, 2013.
- [2] J.-Y. Shiau and M.-C. Lee, "A warehouse management system with sequential picking for multi-container deliveries," *Comput. Ind. Eng.*, vol. 58, no. 3, pp. 382–392, Apr. 2010.
- [3] R. L. Harper, "Warehouse technology in the supply chain management systems," in *Reliability and Maintainability Symposium (RAMS), 2010 Proceedings - Annual, 2010*, pp. 1–5.
- [4] Timm Gudehus, *Logistik - Grundlagen - Strategien - Anwendungen*. 2005.
- [5] J. A. Tompkins, J. A. White, Y. A. Bozer, and J. M. A. Tanchoco, *Facilities Planning*, 4 edition. Hoboken, NJ; Chichester: Wiley, 2010.
- [6] K. Moeller, "Increasing warehouse order picking performance by sequence optimization," *Procedia - Soc. Behav. Sci.*, vol. 20, pp. 177–185, 2011.
- [7] S. Carantino, "Le vocal cherche sa voix," *Stratégie Logistique*, pp. 24–35, Jul-2012.
- [8] B. Schwerdtfeger, "Pick-by-Vision: Bringing HMD-based Augmented Reality in the Warehouse," Institut für Informatik der Technischen Universität München, 2009.
- [9] S. Gharbi, H. Zgaya, S. Hammadi, "Optimization of order picker path based on agent communication in warehouse logistics," *6th IFAC*

Conference on Management and Control of Production and Logistics, Fortaleza, Brazil, 11-Sep-2013.

- [10] V. Geroimenko, "Augmented Reality Technology and Art: The Analysis and Visualization of Evolving Conceptual Models," in *2012 16th International Conference on Information Visualisation (IV)*, 2012, pp. 445–453.
- [11] R. T. Azuma, "A survey of augmented reality," *Presence Teleoperators Virtual Environ.*, pp. 355–385, Aug. 1997.
- [12] E. Sayed, N. A. M. H. H. Zayed, and M. I. Sharawy, "ARSC: Augmented Reality Student Card--An Augmented Reality Solution for the Education Field," *Comput. Educ.*, vol. 56, no. 4, pp. 1045–1061, May 2011.
- [13] I. E. Sutherland, "The Ultimate Display," *Proc. IFIP Congr.*, pp. 506–508, 1965.
- [14] S. Lee, J. Lee, A. Lee, N. Park, S. Lee, S. Song, A. Seo, H. Lee, J.-I. Kim, and K. Eom, "Augmented reality intravenous injection simulator based 3D medical imaging for veterinary medicine," *Vet. J. Lond. Engl. 1997*, vol. 196, no. 2, pp. 197–202, May 2013.
- [15] J. Fischer, M. Eichler, D. Bartz, and W. Straßer, "A hybrid tracking method for surgical augmented reality," *Comput. Graph.*, vol. 31, no. 1, pp. 39–52, Jan. 2007.
- [16] M. L. Blair MacIntyre, "Integrating 2D Video Actors into 3D AR Systems.," 2002.
- [17] P. Vate-U-Lan, "An Augmented Reality 3D Pop-Up Book: The Development of a Multimedia Project for English Language Teaching," in *2012 IEEE International Conference on Multimedia and Expo (ICME)*, 2012, pp. 890–895.
- [18] A. Sarwal, C. Baker, and D. Filipovic, "<title>Head-worn display-based augmented reality system for manufacturing</title>," 2005, pp. 115–122.
- [19] A. Y. C. Nee, S. K. Ong, G. Chryssolouris, and D. Mourtzis, "Augmented reality applications in design and manufacturing," *CIRP Ann. - Manuf. Technol.*, vol. 61, no. 2, pp. 657–679, 2012.
- [20] M. Hincapie, A. Caponio, H. Rios, and E. G. Mendivil, "An introduction to Augmented Reality with applications in aeronautical maintenance," in *2011 13th International Conference on Transparent Optical Networks (ICTON)*, 2011, pp. 1–4.
- [21] "Augmented Reality Statistics: What Marketers Really Think," *Hidden*.2011 .
- [22] B. Schwerdtfeger and G. Klinker, "Supporting order picking with Augmented Reality," in *7th IEEE/ACM International Symposium on Mixed and Augmented Reality, 2008. ISMAR 2008*, 2008, pp. 91–94.
- [23] "Knapp met en place un système de préparation de commandes à guidage visuel," *Logistiques Magazine*, 09-Jan-2011.
- [24] M. Bruno, "Le guidage vocal se répand dans l'entrepôt," *Logistiques Magazine*, pp. 40–46, Jun-2010.
- [25] J. Gobert and N. Renous, "Réalité Augmentée à l'Ensicaen," 2010.
- [26] ISO/IEC 18004/2000, "Information technology-Automatic identification and data capture techniques-Bar code Symbolology-QR Code," 2000.
- [27] Y. Liu, J. Yang, and M. Liu, "Recognition of QR Code with mobile phones," in *Control and Decision Conference, 2008. CCDC 2008. Chinese*, 2008, pp. 203–206.
- [28] P. Suthesbanjard and W. Premchaiswadi, "QR-code generator," in *Knowledge Engineering, 2010 8th International Conference on ICT and*, 2010, pp. 89–92.
- [29] M. Verwijmeren, "Software component architecture in supply chain management," *Comput. Ind.*, vol. 53, no. 2, pp. 165–178, Feb. 2004.
- [30] Generix Group, *Réalité augmentée | Generix Group présente la première application de lunettes connectées en entrepôt avec Oscaro.com*. 2014.