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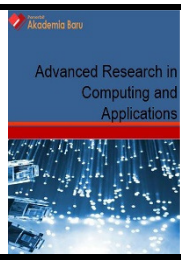

Review of augmented reality applications in manufacturing engineering

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ABSTRACT

Augmented Reality is one of the most significant and remarkable trends in the manufacturing field, where the ability to test and evaluate products in the real world environment before deploy it to market, makes AR as an important factor in manufacturing development process, however, AR researches still few and most of it not up-to-date, because AR applications is very limited in manufacturing field. This paper gives a pilot review on the most applications of Augmented Reality in manufacturing engineering, in order to urge researchers and Augmented Reality scholars to focus and study them, hopefully to expand Augmented Reality applications in manufacturing. This paper focus on giving simple idea about the main points that Augmented Reality covers in relation to the manufacturing stages.

1. Introduction

The rapid advances in computer hardware and software drive manufacturing engineering designers and new technology pursuers to follow these advances and try to benefit as possible from them in the process of manufacturing in order to increase productivity, reduce time and cost, and enhance quality and efficiency. Augmented Reality is one of these remarkable advances in computer technology. It combines a prototype graphic design for the expected final product with a live image for the real world, so products designers can make many studies and analysis before developing the final product. AR in manufacturing becomes an industrial importance since it provides a real-time information about the manufactured parts in their various development phases, such as designing, setup planning, production scheduling, machining and assembly [1]. In 1992, Tom Caudel and David Mizell were the first who used the Augmented Reality in manufacturing when they developed an Augmented Reality system to help workers in Boeing Co. in assembling wires and cables for aircrafts [2]. Caudell and Mizell developed a head mounted device called “HUDset”, the device consists of

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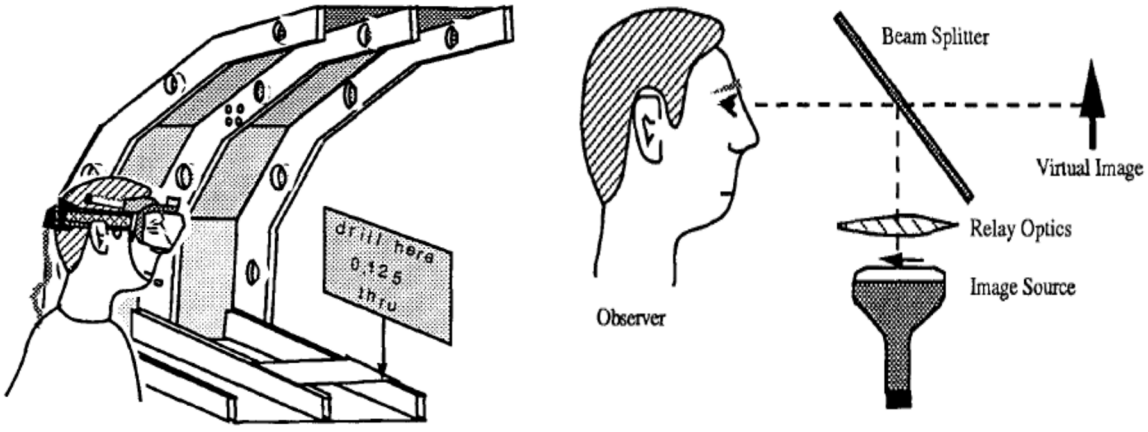
three parts: beam splitter, relay optics and source image. The beam splitter allows user to see image of the real world and 3d graphic simultaneously, relay optics used to generate virtual image of the image source [3] (see Fig. 1).



(a) (b)

Fig. 1. (a) Caudell and Mizell "HUDset" help worker in dynamically mark the position of a drill/rivet hole inside an aircraft fuselage. (b) HUDset components.

2. Applications of AR in manufacturing

Caudell and Mizell device opened the door for other applications of AR in the manufacturing field, where many manufacturers start making researches in how to apply AR in their various stages of manufacturing life-cycle, because there is a great challenge of survive against the global competition of reducing the cost and time, enhancing products quality, and perform flexible products design. The main objective of applying AR systems in modern manufacturing systems is to simulate, assist and improve manufacturing process to solve problems before deploying their service, products or process [4].

AR applications in manufacturing industries extended in all manufacturing process stages, and it is difficult to state all of them in journal paper. So, this paper will classify them according to the famous manufacturing process phases. Respectively, the planning, design, assembly, and maintenance stage. And will give sample of each as illustration.

2.1. AR applications in design stage

Today design stage depend on computer application and the advance in virtual reality in order to increase quality and reduce processing time and costs, and with the innovation of the AR in manufacturing, the design stage become more flexible, where the design of the product can be reviewed, evaluated and adjusted before preceding to the next stages of production [5]. AR systems enable interactive, tele-presence, rapid creation and analysis of virtual models in real environment. Where it helps in earlier decision making on product's shape, assembly, material, tolerance before bringing product to the real life. AR application in the design stage made a significant reduction in time and cost because products can be virtually manufactured and assembled while the product still in earlier stages [6]. Some researchers divide AR current application in manufacturing design stage into two categories [7], the first one used for allowing to visualize, inspect and modify 3D models collaboratively and called "Visualization –based design", and the other concentrate on offering more

collaborative design where the design controlled by remote designer or expert, and they call it "Co-design system".

2.2. AR applications in planning stage

The planning stage in manufacturing needs real data to help in expecting and evaluating the proposed design for the product or the service, and with the ability to test (simulate) the planning data in real environment without the need of modeling the surrounding environment [8]. As shown in figure 2, with the use of AR systems manufacturers can simulate the planning of products processing and assembling in real environment by the aid of computer CAD software. This make the operation of evaluation and analysis of the planning of product processing and assembling very easy and without costing time and money. However, in systems not using the AR technology modifying in products processes or assembly plans will cost materials, wastes, efforts and time, beside the loosing of money and high investment expenses.

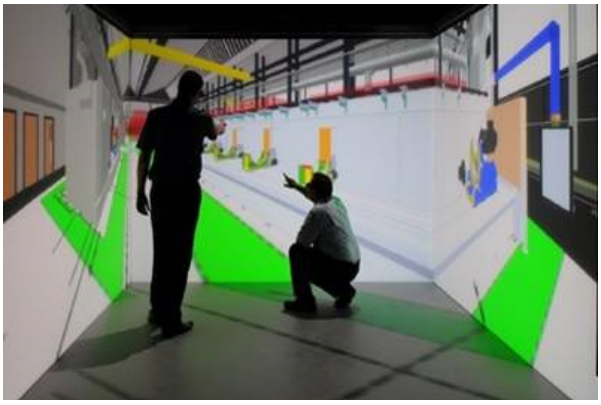


Fig. 2. Using AR in manufacturing planning stage help in simulate the planned data into real environment.

The main benefit of applying AR in the planning stages is to assist manufacturing designers in avoiding possible errors which normally occurs in planning stage. Where AR enables the planner to select, place, replace and manipulate 3D models of machines, devices or material handling systems, in easy way and without any real costs [9]. This because planners can virtually plan manufacturing processes, assembly, factory floor, and costs [6].

Fig. 3. Virtual planning using AR helps to analysis and evaluate products before really built.

2.3. AR applications in assembly stage

The use of AR in assembling processes helps in increasing quality of assembly sequences assessment [10]. Since AR allow worker and assembly designer to observe and evaluate the assembly process in virtual world, in real world they can avoid errors and reduce time and cost [11]. As an example of that, Caudell and Mizell device (the "HUDSet") was developed to help Boeing workers in wiring assembly for Boeing aircrafts.

With AR application in assembly phase, the worker easily can know the exact location, order of assembling, and orientation of the assembly part [12], for example in UK Anglyph Ltd. Corp. developed a special AR software help in laying composite layers, so the technician of the composite can see in the virtual part of the AR software where exactly to position the part and the correct orientation to lay it down.[13] Another AR software called Virtools made by French company called "Dassault Systems" helps also in study the behavior of composite layer to find out the best position to lay out the layers (see figure 5) [13].

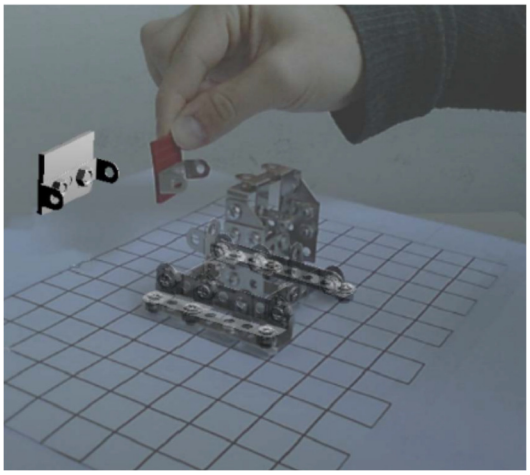


Fig. 4. Assembling of the product parts become easier and faster with the application of AR in assembly stage.

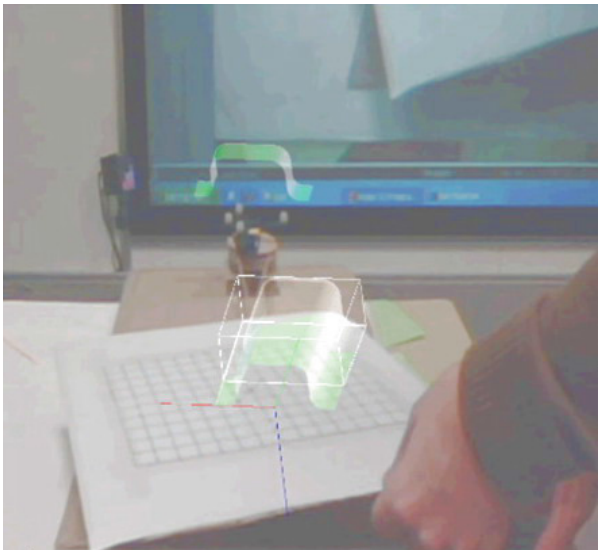


Fig. 5. Virtools is an AR software helps the technician to study and examine the best laying of composite layers.

2.4. AR applications in maintenance stage

Although using AR systems in manufacturing's maintenance stage is still not used widely, the studies on AR systems which are already implemented in maintenance stages, shows promising results in saving time, reducing errors rates, beside reduction of cognitive load of the workers [14]. AR systems offer a great change in convenient maintenance systems, where the information ,instructions and manuals becomes available virtually and the worker can edit and interact with product parts without need to do it in real life [15].

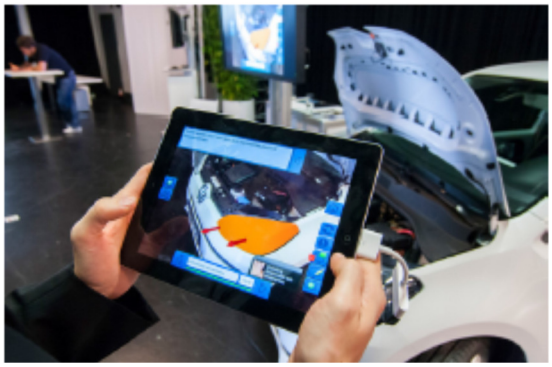


Fig. 6. Application of AR in maintenance provide fast and easy wat to maintain products

One of the successful practices in using AR in maintenance stage, is to offer a remote maintenance tasks, where an expert technician or system can give remote instructions, step by step directly in real scene [16].

4. Conclusion

This paper gives a pilot review of the applications of Augmented Reality systems in manufacturing sector, classified into the stages of the manufacturing process. Hopefully, it may give simple guide for readers who are interested in gain acknowledge about the real implementations of this amazing innovative information technology, which produced the ability to mix the real world environment with virtual world in order to improve the quality and flexibility for products design and assembly. And sequentially, will reduce the time cycle and costs.

References

[1] Mourtzis, D., M. Doukas, and D. Bernidaki. "Simulation in Manufacturing: Review and Challenges." *Procedia CIRP* 25 (2014): 213-229.

[2] Daponte, Pasquale, Luca De Vito, Francesco Picariello, and Maria Riccio. "State of the art and future developments of the Augmented Reality for measurement applications." *Measurement* 57 (2014): 53-70.

[3] Caudell, Thomas P., and David W. Mizell. "Augmented reality: An application of heads-up display technology to manual manufacturing processes." In *System Sciences, 1992. Proceedings of the Twenty-Fifth Hawaii International Conference on*, vol. 2, pp. 659-669. IEEE, 1992.

[4] Nee, A. Y. C., S. K. Ong, G. Chryssolouris, and D. Mourtzis. "Augmented reality applications in design and manufacturing." *CIRP Annals-Manufacturing Technology* 61, no. 2 (2012): 657-679.

[5] Mendívil, Eduardo González, Rocío Esmeralda Naranjo Solís, and Horacio Ríos. "Innovative augmented reality system for automotive assembling processes and maintenance: An entrepreneurial case at Tec de Monterrey." In *2013 15th International Conference on Transparent Optical Networks (ICTON)*, pp. 1-4. IEEE, 2013.

[6] Lu, SC-Y., M. Shpitalni, and Rajit Gadh. "Virtual and augmented reality technologies for product realization." *CIRP Annals-Manufacturing Technology* 48, no. 2 (1999): 471-495.

[7] Elia, Valerio, Maria Grazia Gnoni, and Alessandra Lanzilotto. "Evaluating the application of augmented reality devices in manufacturing from a process point of view: An AHP based model." *Expert Systems with Applications* 63 (2016): 187-197.

[8] Pentenrieder, Katharina, Christian Bade, Fabian Doil, and Peter Meier. "Augmented Reality-based factory planning-an application tailored to industrial needs." In *Mixed and Augmented Reality, 2007. ISMAR 2007. 6th IEEE and ACM International Symposium on*, pp. 31-42. IEEE, 2007.

[9] Fruend, J., and C. Matysczok. "Designing flexible manufacturing systems with augmented reality." In *Augmented Reality Toolkit, The First IEEE International Workshop*, pp. 3-pp. IEEE, 2002.

[10] Suárez-Warden, Fernando, Eduardo González Mendívil, Ciro A. Rodríguez, and Salvador Garcia-Lumbreras. "Assembly Operations Aided by Augmented Reality: An Endeavour toward a Comparative Analysis." *Procedia Computer Science* 75 (2015): 281-290.

[11] Raghavan, Vijaimukund, Jose Molineros, and Rajeev Sharma. "Interactive evaluation of assembly sequences using augmented reality." *IEEE Transactions on Robotics and Automation* 15, no. 3 (1999): 435-449.

[12] Novak-Marcincin, J., J. Barna, M. Janak, L. Novakova-Marcincinova, and J. Torok. "Visualization of intelligent assembling process by augmented reality tools application." In *2012 4th IEEE International Symposium on Logistics and Industrial Informatics*, pp. 33-36. IEEE, 2012.

[13] Fečová, Veronika, Jozef Barna, Jozef Novák-Marcinčin, Miroslav Janák, Ľudmila Nováková-Marcinčinová, and Jozef Török. "Visualization of composite lay-up technology with use of augmented reality elements." In *Applied Machine Intelligence and Informatics (SAMI), 2012 IEEE 10th International Symposium on*, pp. 173-177. IEEE, 2012.

[14] Nikolic, Vesna, Peter F. Elzer, and Christian Vetter. "A monitor-based ar system as a support tool for industrial maintenance." *IFAC Proceedings Volumes* 39, no. 16 (2006): 902-907.

[15] Nee, Andrew YC, and Soh-Khim Ong. "Virtual and augmented reality applications in manufacturing." *IFAC Proceedings Volumes* 46, no. 9 (2013): 15-26.

[16] Caricato, Pierpaolo, L. Colizzi, Maria Grazia Gnoni, Antonio Grieco, Antonio Guerrieri, and Alessandra Lanzilotto. "Augmented reality applications in manufacturing: a multi-criteria decision model for performance analysis." *IFAC Proceedings Volumes* 47, no. 3 (2014): 754-759.