International Journal Of Applied Research In Science And Engineering *ISSN (Online): 2456-124X*
International Conference on Emerging Technologies in Engineering, Biomedical, Medical and Science
(ETEBMS - November 2016)

AN OVERVIEW OF AUGMENTED REALITY IN VARIOUS FIELDS OF MECHANICAL ENGINEERING

Shivani Singh
B.Tech Final Year Student, JNU Jodhpur

Abstract: Augmented reality, blurs the line between what's real and what's computer-generated by enhancing what we see, hear, feel and smell. Taking the technology to the next level, where engineers can display hidden items such as underground utilities using a small tablet or smartphone, for instance, is a lot trickier and a lot more difficult. In this paper, the introduction, application and future scope of augmented reality in fields like Mechanical, Automotive, Aerospace and Aviation Engineering is reviewed to reveal their great potentials. "The potential for augmented reality is great but achieving it is extremely difficult," says Stephane Cote, a research director and fellow at Bentley Systems in Quebec. "For engineering accuracy is extremely important. You're having an impact on people's lives. You need accurate data"..

I. INTRODUCTION

VIRTUAL reality allows gamers to experience being in a three-dimensional environment and interacts with that environment and other players during a game. While virtual reality definitely has its place in a myriad of different industries, what about the possibility of combing some of these virtual realities with real-life situations? An enhanced reality where the user can see and experience the real world around them, but with the addition of computer-generated images and objects in conjunction with what's really there: enter augmented reality (AR). AR can be used in almost every phase of design and manufacturing, from the initial concept and design phase, in which you are reviewing and evaluating concepts and alternatives as they would appear in the real world, to the manufacturing phase, in which process steps, assembly examples and quality control information can be superimposed into an actual work environment. AR can provide detailed information on maintenance procedures, overlaying them directly onto your part or machine. You can even use AR in marketing your product or design, showing different configuration options and how the product might look in a client's setting. Regardless of your title or which phase of the design and manufacturing process you are in, AR is something to continue to watch and gain exposure to. AR can help us more efficiently interpret 3D digital data and how it relates to real-world environments. Communicating our designs with other team members or potential clients is also enhanced with AR, which can mean more accurate designs, quicker timelines from design to manufacturing and increased sales. This paper introduces the great potentials of augmented reality in the engineering communities. We first give the overview of augmented reality in the fields and then introduce the basics of these technologies with the applications, advantages and disadvantages and future scope with the technical methodology. The focus of this paper is on the use of these technologies to solve the challenges in the various fields, emphasizing the great potentials that these applications can lead to many exciting new paradigms in engineering profession. The paper also identifies areas where more joint R&D efforts are needed from the engineering and mechanical communities to make augmented reality technologies a true reality for the real-world practice in the near future.

II. OVERVIEW OF AUGMENTED REALITY IN MECHANICAL ENGNEERING AND RELATED FIELDS

Augmented reality (AR) is a variation of virtual reality (VR). The components of AR systems are similar to those of VR systems. AR systems, however, are not aimed at immersion of the users in a virtual environment. Rather, the goal of AR systems is to superimpose (i.e., augment) computer-generated graphics over real objects in the user's field of view as if they appear in the real world. Thus, a STD (see through device) is used by the user, which eliminates the need to model the environment. This saves not only a lot of modeling effort but also reduces by factors the information needed to be generated and transferred in real time (which is the main technological drawback of VR). Therefore, AR systems exhibit more application potentials than do VR systems at the present time.(ME1). Augmenting necessary information can enhance the user's perception and improve his interaction with the real world by supplying him with necessary diagrams, step-by-step instruction, real-time animations, and other data that is essential for his work. These augmentations should be correctly aligned (registered) with the real objects they represent. Due to the relatively simple graphics displayed in AR systems, a complete 3-D model of all objects in the field of view is not necessary as in the case of VR systems. Some objects might be modeled in detail, while others appear only as a wire-frame. Typically, most of the user's view would be from the real world. For this reason, AR systems do not need to be driven by the same graphic engine used in a VR system in order to supply a sufficient frame rate. 3-D manipulation of smaller models can be handled by much cheaper equipment in AR systems.

A. Manufacturing

Manufacturing Science

The result of applying VAR involves the virtual generation of product design, product planning, product delivery, product maintenance, and product recycling. The technical challenges within each of these stages are outlined as follows

Designing

Virtual designing refers to decisions on product shape, product assembly, product material, tolerance, etc., before the product is built, i.e. when the product is still "virtual". The challenges herein are the representation of product design, creation of a natural interface for interaction between the human and the computer, management of the data and the product definition over the distributed design environments, etc

Planning/Manufacturing

Planning for manufacturing using Virtual Product Realization involves virtual manufacturing process plan generation, virtual assembly planning, virtual factory floor planning, virtual cost analysis, etc. The challenges in virtual planning/manufacturing involve acquisition and modelling of manufacturing knowledge from the manufacturing shops, acquiring knowledge of assembly, acquiring knowledge of cost, performing market research, so as to input all sets of knowledge with the AR systems.

Delivery –

This involves planning through information systems, delivery of the product through salespersons and finally to the customers. The challenge here is largely a database and data distribution issue.

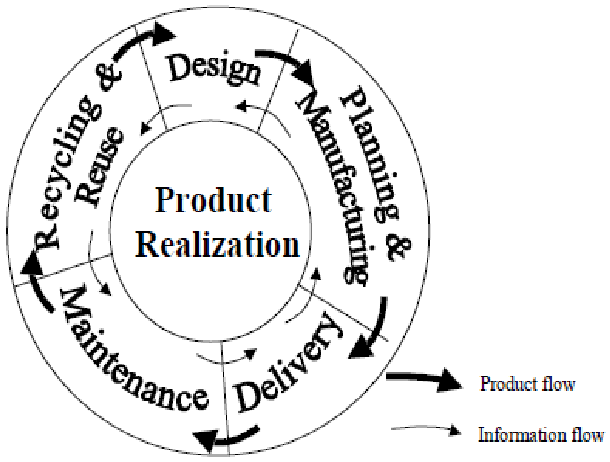
Servicing –

Ensuring that the product is serviceable requires ensuring that the product is easily dismantled/disassembled, is easy to put together again (re-assemble), is made of material that can be easily handled, etc. It for servicing involves disassembly, re-assembly, etc. of product designs, and such analysis can typically be performed in a AR-based environment. Virtual servicing involves bringing in a large variety of such software tools into the AR environment.

Recycling –

A product is easy to recycle if it can be disassembled and its material can be reused. Virtual recycling is a significant challenge up front at the product design stage. Challenges involve creating sufficient knowledge bases of materials that interact with the product shape/definition to affect recycling .

This would involve integration of geometry, material, manufacturing processes, knowledge bases, etc., within a user-friendly user interface.



B. Automotive Engneering

Engine Maintenance

For the diagnosis of maintenance and repair tasks, modern cars provide a systeminterface (mostly via a plug-like connector). While this interface allows for very fastand precise analysis of the state of the engine, the accompanying information is stillfound on a dedicated PC or on print-outs. Hence, the object to which the diagnosis isapplied (part of the engine) and the resulting data yielded by the diagnosis arespatially separated. AR has the potential to close this gap, enabling the diagnosisresults to be displayed right in immediate proximity to the engine.

There are many important questions that must be considered, however: What kind of information is useful, and should it be represented? What are the technological alternatives available for solving this? If the data is very complex, as it often is, where and how do you place the information at the engine? These were the issues we had to address when implementing a prototype application for a real Mercedes-Benz (8 cyl. SL) engine. Again, an HMD-based solution connected to a portable PC (alternatively, a notebook computer) was chosen. The tracking of the user's position and orientation was done using a marker-based approach. In this case markers were attached to a U-shaped object which was placed into a certain location at the engine. The use of multiple markers at well-defined positions provided us with reasonably precise tracking.

C. Aerospace

The advantages and benefits of AR have been widely applied by important aircraft manufacturers in global market. This section shows some related work beyond typical usage of AR on a synoptic analysis.

Boeing Case

One of AR studies developed at Boeing was in partnership with Iowa State University described in the work "Fusing Self-Reported and Sensor Data from Mixed-Reality Training" in order to evaluate three different methods of presenting work instructions.

Fig – 2 Boeing Case

Airbus Case

Fig. – 3 Airbus Case

Airbus develops its product family in response to market needs and in close consultation with airlines and operators, suppliers and aviation authorities. This approach ensures the company's products to remain competitive through continuous upgrades. The company produces and markets the world's largest passenger airliner, the A380 With the master for a new aircraft production process developed entirely with digital tools, Airbus collaborated to create the MiRA (Mixed Reality Application) in 2009.

This app increases productivity in production lines by using AR to scan parts and detect errors. On the A380, MiRA, which today consists of a tablet PC and a specifically developed sensor pack and software, has reduced the time needed to check tens of thousands of brackets in the fuselage from 300 hours to an astonishing 60 hours. Furthermore, late discoveries of damaged, wrongly positioned or missing brackets have been reduced by 40% [18]. Fig. - 4shows a bracket inspection with MIRA solution.

Fig –4 Bracket inspection with MiRA Solution

In the more commercial aerospace world, Airbus is using a technology known as MIRA, or Mixed Reality Application, where engineers installing equipment inside aircraft fuselages use a tablet computer and a sensor pack, which tracks their position and relates it to a Realistic Human Ergonomics Analysis (RHEA) tool, a full-scale 3D digital model of the aircraft they are working on. This enables them to call up an image of a bracket installation in the area where they are working to ensure that they have fixed it correctly. Geo-location devices attached to the aircraft interact with the sensor pack to allow them to view their work location from any angle. The RHEA is updated as each component is installed. This technique has helped reduce the time to inspect the 80,000 brackets inside an A380

III. APPLICATIONS

Education

This application depicts a physical interface (augmented book) relying on augmented reality technology for learning standard mechanical components. Such book has been contained in the course of an engineering graphics subject in a mechanical engineering degree of a Spanish university.

Fig – 5 EXAMPLES OF HEX-HEAD SCREW

Fig – 6 Example of Hex-Nut Screw

2.Machinery System Design

The machinery systems design is one of the AR applications which are concerned with enhancing product design and development. This application focuses on a different engineering instrument. Hence, design and its related matters are submitted in a limited way. It is probable to utilise the AR technology in Design, with the desire that in sometime in the future it may become a complemen- tary part of a standard design process of more dependable and resilient machinery systems. The basic aim of the applied application was to help designers of machinery system to design more dependable mobile robots. Know- ledge embodied in a procedural form should be utilized during the design process in order to remove causes of incompetence in the upcoming products. Such knowl- edge is stored in a knowledge database which is gained from experts as indicated in Fig - 6.

Fig – 6 Previewing data from a database

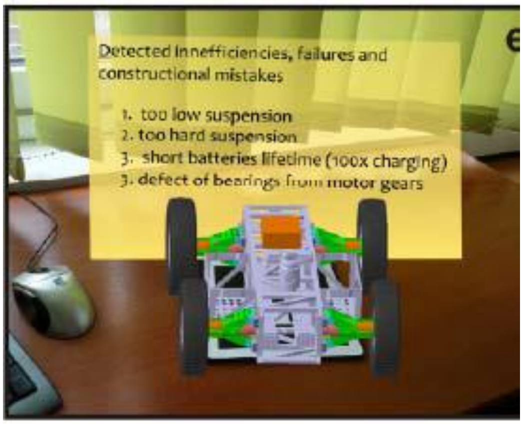


Fig - 7 Viewing instructions or procedures concerning design process

3. Maintanence and Repair

Many contributions have interested the area of aerospace applications. An optical device has been used to recognize markers placed on aircraft components. As illustrated in Fig. - 8, the user can position a see-through combiner lens in front of either eye and receive virtual text information from the system.

Fig – 8A mobile AR system with HMD used in aircraft maintenance activities.

The detailed sequence of operations to be performed in a oil-check procedure is visualized by the system proposed in [7] and shown in Fig.4: a red 3D rectangle frames the information to remind the operator to read it, (Fig.4.a); the model of the oil dipstick rotates counterclockwise and moves upward to indicate the operation to be emulated (Fig. the different oil levels are shown using color-coded information

Fig - 9. Oil check procedure of an aircraft supported by an AR video mixing

The maintenance activities concerning a Rolls-Royce Dart 510 turboprop engine have been investigated in. In particular, an AR prototype for providing assistance during procedural tasks has been developed. Fig.10 shows an example concerning the correct alignment of combustion chamber parts: a red and dynamic arrow indicates the needed motion in direction and magnitude (Fig. -10.a); the arrow changes size and color as can and cone begin aligning (Fig.10 -.b) and, if necessary, specifies shortest rotational direction to alignment (Fig. -10.c); the arrow disappears when alignment is achieved (Fig -10.d).

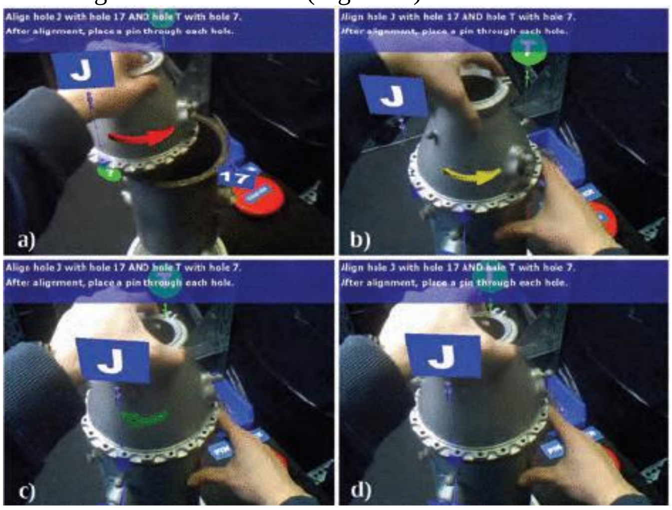


Fig - 10 AR procedure for supporting operator in performing maintenance taskon a combustion chamber of a Rolls-Royce Dart 510 engine.

An example in the automotive sector is given in. In this application, a BMW 7-series engine was used to test the system. The solution for AR-based repair guidance consists of a markerless CAD-based tracking system able to deal with different illumination conditions during the tracking stage and to automatically recover from occasional tracking failures. Two hardware solutions were experimented, based on a wireless mobile setup: a monocular full-color video-seethrough HMD and with a monochrome optical-see-through HMD (Fig. - 11)

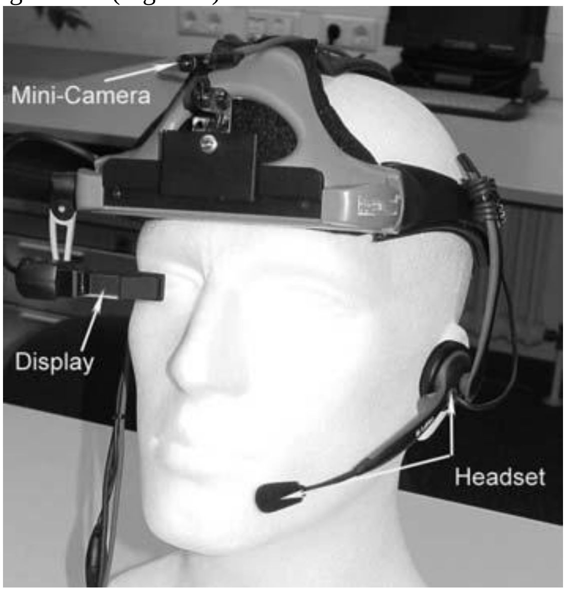


Fig – 12 Head mounted display (HMD)

Fig. - 13. Optical see-through HMD used in the maintenance procedure of a commercial vehicle.

4. Diagnostics, fault detection, inspection and testing
Some car manufacturers are developing AR-based diagnostics systems to be used in workshops. The solution depicted in fuses object recognition, tracking and task oriented user interfaces to deliver unparalleled workshop efficiency. Parts and components that need to be analyzed are marked and presented in a display that allows a step-by-step diagnostics. In, the data from the sensors, such as tire air pressure, are analyzed and presented in visual form on a HHD. The proposed solution overlays virtual information in the exact position of the vehicle corresponding part.

Fig. -14 AR diagnostic system used in car workshops. The worker points histablet at the vehicle and receives an immediate diagnosis of the major systems in real-time.

IV. LIMITATIONS

Today, AR faces several technical challenges regarding stereo view, color depth, luminance, high resolution, contrast, focus depth and field of view. Researchers have begun to address problems indisplaying information in AR displays that are caused by the nature of AR technology or displays. Workhas been done in visualizing the registration errors, avoiding hiding critical data due to density problems and at the same time not cluttering the screen with excessive information. However, before AR becomesaccepted as part of the user’s everyday life, issues regarding intuitive interfaces, cost, weight, powerusage, ergonomics, and appearance must also be addressed. Some of the major problems are discussedbelow.

1. Portability and Outdoor Use: Most mobile AR systems are bulky and cumbersome,requiring a heavy backpack to carry the PC, sensors, display, batteries, and other components. Connections between all the devices must be able to withstand outdoor use, including weather and shock. Optical and video see-through displays are usually not suited for outdoor use due to low brightness, contrast, resolution, and field of view. However, laser-powered displays offer a new alternative to overcome this problem.

2. Tracking and Calibration: Tracking in unprepared/outdoor environments remains a challenge but hybrid approaches are becoming small enough to be added to mobile devices. Calibration of these devices
is still complicated and extensive, but it may be solved through calibration-free or autocalibrating approaches that minimize set-up requirements.

3. Latency: A major source of dynamic registration errors are system delays. Techniques like precalculation, temporalstream matching and prediction of future viewpoints may solve some delay. Through careful system design, system latency can be scheduled to reduce errors and pre-rendered

images can be shifted at the last instant to compensate for pan-tilt motions. Likewise, image warping may correct delays in 6DOF motion (both translation and rotation).

4. Depth Perception: Problems such as accommodation vergence conflicts or low resolution and dim displays cause object to appear further away than they really are. Correct occlusion ameliorates some depth problems, as does consistent registration for different eye point locations. In an experiment by Biocca and Rolland (1998), subjects exhibit a large overshoot in a depthpointing task after removing the HMD.

5. Data Density: If the real world is augmented with a large amount of virtual information, the display may become cluttered and overpopulated with unnecessary data. The distribution of data in screen space varies depending on the user's viewpoint in the real world. The user interface must follow some guidelines as not to overload the user with information and at the same time must prevent the user from overly relying on the AR system such that important cues from the environment are missed.

6. Social Acceptance: Making AR a part of everyday life may be more challenging than expected, as many factors play a role in social acceptance of AR ranging from unobtrusive fashionable appearance (gloves, helmets, etc.) to privacy concerns. For example, Accenture's Assistant blinks a light when it records for the sole purpose of alerting the person who is being recorded. These issues must be addressed before AR is widely accepted.

7. Adaptation and Long-Term Use: User adaptation to AR equipment can negatively impact performance. AR displays that are uncomfortable may not be suitable for longterm use. One study found that binocular displays, where the same image is shown on, caused significantly more discomfort than monocular displays, in both eye strain as well as fatigue.

V. CONCLUSIONS

In this paper, consideration of factors like applications, quality, time and knowledge gain, helps and often enables the paper to get started. Even if the figures are "educated guesses", estimates of the value added and sometimes even a return on investment appraisal are widely expected. Indeed, this is not the core competence of an AR researcher, but it is to be expected that the researcher will be concerned with these issues. Preferably one can find experts in the field of industrial economics to provide appropriate data or estimates. In a mid-term perspective, augmented reality is on its way to become a productivetool in industry. The spectrum of application fields is very wide and early applications of the technology have already demonstrated its value.

REFERENCES

[1] S. C-Y. Lu, M. Shpitalni, RajitGadh, VIRTUAL ANDAUGMENTED REALITY TECHNOLOGIES FOR PRODUCT REALIZATION

[2] HolgerRegenbrecht, Gregory Baratoff, Wilhelm WilkeAugmented Reality Projects in Automotive and Aerospace Industry

[3] Mauricio A. Frigo and Ethel C. C. da Silva, Gustavo F. Barbosa, Augmented Reality in Aerospace Manufacturing: A Review,Journal of Industrial and Intelligent Information Vol. 4, No. 2, March 2016

[4] Abrar Omar Alkhamisi, Muhammad MostafaMonowar,Rise of Augmented Reality: Current and Future Application Areas, International Journal of Internet and Distributed Systems, 2013, 1, 25-34

[5] G. Dini, M. Dalle Mura, Application of Augmented Reality Techniquesin Through-life Engineering Services,Procedia CIRP 38 (2015) 14 – 23

