International Journal of Engineering Applied Sciences and Technology, 2022
Vol. 6, Issue 10, ISSN No. 2455-2143, Pages 106-110
Published Online February 2022 in IJEAST (http://www.ijeast.com)

USE OF AUGMENTED REALITY IN AUTOMOTIVE PROTOTYPING

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Abstract- **Augmented reality (AR) is a technique to enhance the knowledge about an object. This knowledge is in digital format and available on handy gadgets. On the need basis anyone, anywhere, any object information can be obtained within no time using AR technique. This way one may not require expert physical presence to know about any object. This technique is being very well used in many areas like education, medical, aerospace etc. This technique can be extended in manufacturing process also. One important manufacturing process is the vehicle conversion through automotive proto building, where many parts are to undergo changes. This work require expert presence and his knowledge for assembly and disassembly sequence, appropriate tool usage, correct applications of force and torque, correct parts and their fitment. All these requirements are met with in lieu of time and money in terms of expert presence and manual convey of knowledge. All the above requirements can be addressed through application of digital capability of modern world and one of the application is Augmented Reality (AR) in virtual prototyping. This paper discusses about usage of AR technique in making automotive virtual prototype. The virtual prototype is a handy knowledge bank which help technicians and engineers to perform their job without anyone help & hence save money, reduces turnaround time and avoid errors in the process.**

Keywords— **Augmented reality, Virtual Prototyping, Automotive Proto Building**

I. INTRODUCTION

Augmented Reality and Virtual Reality (AR/VR) are not new, but recent advances in computational power, increased storage capacity, graphics processing and high-resolution displays, have helped in the usage of the widespread use of these immersive technologies. For several years, researches are going on for technologies of augmented reality and has been explored for mobile applications for entertainment systems [1]. A systematic literature review on the application of augmented reality in the automotive industry were performed by Boboc et al. [2]. Luis et al, carried out in-depth studies of different fields where AR/VR has been used [3]. They provided an insight into the AR applications and technologies in the automotive field. Also there are several extensive studies that address the implications and impact of AR on industry, as well as the challenges and directions of development in this field. Masood and Johannes studies augmented reality in support of industry 4 solution and presented implementation challenges and success factor [4].

AR/VR can reduce time and costs, and lead to an increase in quality, in the development of a product. Given the pressure on Automobile companies to reduce time-to-market and to continually improve quality, the automotive industry has championed the use of AR/VR across a number of applications, including design, manufacturing, and training. AR is having great impacts on the automotive industry. Some of the biggest impacts are in heads-up displays, sales, customer assistance, information presentation, engineering, maintenance and training.

The automotive prototype manufacturing require expert knowledge on processes of parts assembly & disassembly and tools usage. These expert knowledge can be captured in digital form and can be kept in central location and can be used contextually anywhere and anytime. This paper discusses a new process using AR technology to convert digitally, the manual transmission passenger car to dual clutch transmission system. This new process have

- Complete Augmented Procedural Guidance for product assembly through Augmented Reality.
- Real-time contextual Procedural Guidance for Inspection & Verification.
- Orchestrate the Product assembly information in mobile and IPad device through AR.

II. METHOD/ PROCESS

AR for virtual prototyping process flow is demonstrated in Figure 1 below.

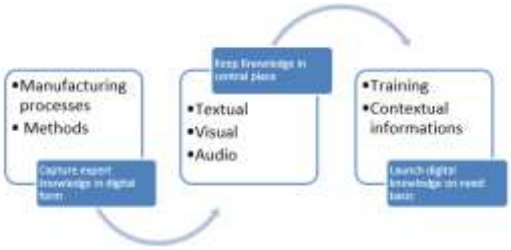

Figure 1: Virtual prototyping process flow

For virtual prototyping, a project of a hatch back car conversion is undertaken of proto shop. This project includes

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conversion of manual transmission vehicle to dual clutch transmission vehicle. To achieve this 50 no. of parts / assemblies of manual transmission vehicle were replaced/modified with dual clutch systems. Following are few major assemblies that changed viz.

a) Gear shifting lever
b) Flywheel & Stiffner Bkt
c) Transmission box & Drive Shafts
d) Cooling layout for DCT Hoses
e) Wiring harness
f) Engine & Transmission mountings

To get an idea, some of the change contents are explained below.
This includes replacement of Dual mass flywheel over conventional single mass flywheel (Figure 2) which is primary requirement of dual clutch transmission. The bolt system also get changed as shown in figure.

Figure 2: Conversion from single mass to dual mass flywheel

Also a major change is in transmission housing and corresponding length change in drive shaft system as shown in Figure 3.

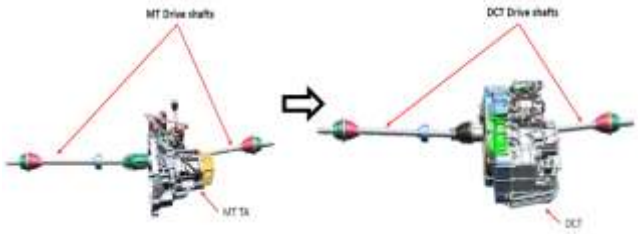

Figure 3: Transmission housing and drive system change

This conversion process is done virtually and explained below. The process of virtual prototype consists of following phases

Phase 1: It comprises of data collection, integration, and preparation of assemblies dis-assemblies. The gathered data, in the format of JT, WRL & STEP are imported into Rapid Manual (Cortona tool for assembly sequencing). Issues such as data loss observed while importing data in Rapid Manual with JT format. Other issue observed while importing through wrl format was auto-scaling of CAD data. All issues overcame with research and alternative methodologies and implied to achieve the requirement. The process can be clearly understood as below.

After the successful import of data in Rapid manual, to define sequencing and motion to the assemblies rapid actions are applied.

The frequently used actions are

- Remove: for removal of components (highlight → transform to defined location → make invisible)
- Install: for installation of components, etc.
- Show/Hide: to define/hide certain object or information to user.

On completion of defining the actions, a video file is generated. This file may be used as an effective tool for classroom trainings. In addition to that a supportive textual document (stepwise) can also be generated.

Phase 2: It requires an Author tool (REFLEKT ONE). Authoring is the process where, CAD data from Rapid manual is converted to visualize it in AR. The process flow of phase 2 is explained below.

Data is prepared by providing respective information (textual guidance for user) insertion to the steps created in the file. The data that imported in author tool needs to have certain referance to physical world so that it can overlay digital data with respect to that referance. Once the authoring process completed, data is published onto the cloud server. The cloud server provides liberty to user, by providing access to AR files over any smart devices.

Phase 3: This will be the final and end result of the process. In this phase, user should have the smart device compatible to REFLEKT ONE app (AR) so as to visualize the compiled data. Once the user is ready with the device and app, there will be a hirerachy which is developed in phase 2.

The hirerachy segregates and allows multiple projects to be embeded. User has to select respective project and follow the process on screen. Once user select 'Launch', it will ask for image reference or object reference whichever method is preferred in phase 2. In this process user has to match the object/image digital data to physical world data. Once it matches, the digital data with all information will appear over the screen.

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III. ASSUMPTION

Basic assumptions in using AR are as below

- One must be knowing complete process where this technique is being used.
- Perfect data is available for usage
- End users knows the operations for usage, if not he is going to be trained
- Data processing capability exist
- Proper tools are available to develop AR application

With above assumptions and realization of these assumptions, help smooth performing in AR development.

IV. OBSERVATION

Augmented reality has been used to make virtual prototype and eventually observed the below facts which is useful for anyone who wants to apply AR in an industrial context.

IV a. Data Integration

The data and usage in AR application are often seriously underestimated. In the real data trial, however, the systems mostly tend to fail because of the quantity of data needed, or the complexity and diversity of the data. Hence the developers and end user need to make data interface smoother in the project. A dedicated workflow and tools (especially authoring tools) need to be developed for successful process integration.

IV b. Acceptance:

The AR technology has not yet reached a level of maturity for widespread deployment and acceptance. Any end users are initially susceptible of usage of this new technology. Hence to make wider acceptability, more mature end user should work with developers. Once the acceptance and maturity for usage is arrived to a certain level, it should be disseminated to others.

IV c. Simplicity:

It is advisable to provide a simple, but accepted solution first, so that technology is adoptable to many users. Once confidence is build, the advance version can be worked at a later time. The AR display and tracking technology should be simple and harness the most advanced and most recent systems available. It should be the most accepted and robust one as it would be always better than offering the latest unreliable & expensive technology.

IV d. Added Value:

Consideration has to be made on factors like cost, quality, time and knowledge gain which helps and often enables the project to get started and become successful. The augmented reality has to be aimed to make it as productive tool for the organization and industry. It has wide application fields and its usage have already demonstrated its value. A comprehensive approach in future research and development with potential users will bring added value to AR.

V. RESULTS

The AR application for virtual prototype resulted to a contextual information of manufacturing process available to handy gadgets to workers. The work yielded digital information on assembly and disassembly sequences of proto making with mechanical and electrical parts, using Cortona software [5] in 1st phase. In the 2nd phase, it launches the contextual information using REFLEKT authoring tool [6]. The final interface (phase3) shows the operator\end users, the detailed information required to carry out their work without any requirement of particular subject matter expert. In virtual Prototyping, all required information are provided like textual guidance, tools required, technical specification, visual guidance on sequencing etc. as shown in Figure 4.

Figure 4: User Interface using AR technique

VI. KEY ADVANTAGE OVER COMPETITORS (BENCHMARKING)

The key advantages of using AR in making virtual prototype are as below-

- AR increases engagement and interaction and provides a richer user experience to proto-shop fitters and workers
- AR increases the perceived value of products and brands to end user
- It provides video support.
- It adds and removes single POIs in real time.
- It can run on any device.
- It offers great performance and memory management.
- It has an exceptionally light view, smooth and accurate movements.
-

VII. SCALE OF INNOVATION

AR adds digital images and data to amplify views of the real world, giving users more information about their environments. AR apps act as a magic window for the viewers that lets them see the holograms and manipulate 3D models. Augmented Reality applications developed in the form of digital visual (audio and other types also) content into the user's real-world environment for prototyping. The expertise can be scaled to other avenues like training, education, work and consumer applications in various industries, healthcare, tourism, gas and oil and marketing.

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VIII. MARKET POTENTIAL

This technique can be extended to other avenues and few are mentioned below.

VIII a. AR use in Literature Cell

AR can be used to make owners and workshop manual application that use AR on a phone or tablet. Using the device's (Cell phone, Tab) camera, these apps can display information or directions right on top of particular features as shown in Figure 5. Walking around the car component, these apps display contextual information.

Figure 5: Contextual information display by AR application (Photo courtesy: google-techsee.me › blog › augmented-reality-instruction-manual)

VIII b. AR use in Education Cell

AR can be used to create interactive learning environments & for enabling faster and more effective learning. 3 D interaction can be generated to visualize the assembly\parts in interactive manner as shown in Figure 6. Students can see components in action, rotate them, and zoom in and out. The app can also give detailed information about each components. This idea can be applied in each stream of engineering education, for example mechanical, civil & electrical etc.

Figure 6: 3D interaction application by AR for education (Photo courtesy: google-techsee.me › blog › augmented-reality-enterprise use cases)

VIII c. Manufacturing line Simulations

The main challenge in manufacturing line is the variation of car launches. Every car launches has its own manufacturing assembly disassembly sequence, process and parts. Many workers are to be trained to work in manufacturing line for these launches. The augmented reality can be used for training the launch process for complete line as well to individual work station, as shown in Figure 7. This will lead to more planning reliability and consequently to a reduction in time and cost.

Figure 7: AR application in manufacturing line (Photo courtesy: google-insights.samsung.com)

VIII d. KM repository

The business units of any organization has lot of knowledge which can be digitized through Augmented Reality. This way digitized knowledge can be more interactive knowledge bank and can be used as repository for training and ready reference. The typical examples are knowledge of EV, connected, autonomous and industry 4 solutions.

VIII e. Sales

AR can be used in the car showroom where one can get overlaid information about every option, financing and weight, performance, mileage etc. using smartphone camera. This satiate the buyers for his queries on purchase interest. Customer can walk around the car, get different options on colors, vehicle accessories, trims and other features as shown in Figure 8.

Figure 8: AR application in showroom of Cars (Photo courtesy: google-robbreport.com)

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VIII f. Engineering

AR can be very well used in design and manufacturing stages. While designing the car, various options of color, components, fit & finish can be explored through AR, for optimized design as shown in Figure 9. AR offers manufacturing line workers about craftsmen crucial information through display in front of them that display complete information of the parts as they are going to install. They can also check with information on the screen showing appropriate options apply to that station, leading to improve both speed and quality of assembly.

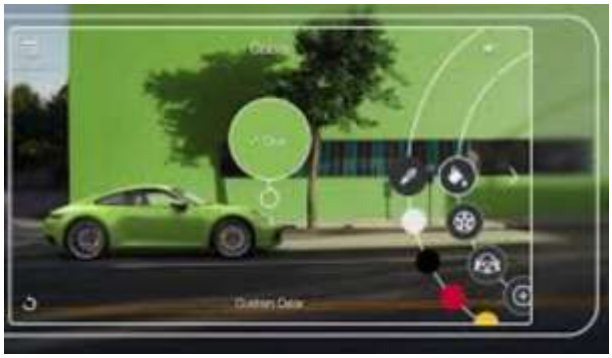

Figure 9: AR application in car design
(Photo courtesy: google-motorauthority.com)

IX. BENEFIT TO ORGANIZATION

Augmented reality (AR) involves overlaying visual, auditory, or other sensory information onto the world in order to enhance one's experience. Augmented reality can be used to promote products or services, launch novel marketing campaigns, and collect unique user data. More business can be developed by cross deploy the AR techniques for different commercial and passenger vehicle platforms of OEMS as well as to other customers of TTL. In future AR technologies can be extended in education field also.

X. CONCLUSION

Augmented reality will certainly continue to have a huge impact for decades to come in automotive industry. The AR is very well used for virtual prototyping which reduced the prototyping process time by approximately 30%. Also it reduced the errors in assembly and disassembly process. AR also decreases the dependency on expertise and give freedom to workers. This is also helpful in tools information for their accurate usage. Fit and finishes were also possible to check in prototype building.

XI. RECOMMENDATION

AR enhances the user experience with just a matter of few clicks and give access to just-in-time information, anytime, anywhere. These technologies empower people to time travel into the past from anywhere using a simple headset or other immersive device. AR is recommended for enhancing knowledge in educational, medical training, retail, repair & maintenance, design & modelling, business logistics, tourism Industry and field services.

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