A theoretical framework development of Augmented Reality and its Application in different sectors

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ABSTRACT *The paper discussed about concept of Augmented Reality (AR) and its application in different sectors. Augmented reality can be used in different sectors for making processes smart and intelligent. In manufacturing sector augmented reality is an integrated element of intelligent manufacturing (Industry 4.0). Paper is further divided into three sections. The section first consists of review of literature on AR. The second section identifies different elements of AR from literature and by expert's opinion and develops a framework. In last section authors discuss application of AR in different sectors and future areas of research and application.*

Keywords: *Augmented Reality, Manufacturing, Applications, SCM.*

1. Introduction

Augmented Reality (AR) is one of the efficient and effective tools for modern technology application. AR acts as eyes and ear for industries as it helps an individual to supervise and also assists them for the work they are performing. Augmented Reality also adds some useful information to the world and environment of the user. AR creates new things in an individual's space and gives new live experiences. AR system can be used in manufacturing sectors for various services like selection of spare parts and evaluating them during repairing and overhauling. This can also improve decision making and working procedures. An AR system adds the real world with virtual (computer-generated) entity that emerges to coexist in the same space with the real world (Azuma et. al, 2001). Therefore, it can be said that AR communicates with individual and increase its working efficiency by assisting with the information about the instruments and working environment. Section 2 discusses AR related literature. Section 3 discusses applications and future areas of research in AR. Section 4 Conclusion.

2. Review of related Literature

Neumann and Majoros (1998) discussed that how AR can help and be valuable to human tasks. Authors have interconnected a number of attribute that make AR appealing as an information technology for manufacturing and maintenance. Authors further observed that this field is very promising. Höllerer et al. (1999), explained by an experiment on mobile AR system that AR can help to access any outdoor individual to interact with the activities of any indoor activity, like in any assembly industry and any indoor individual with that of outdoor scenes by the help of AR devices like head-tracker, head worn devices, hand held pen-based computer etc. AR is a technology that unites virtual entity to real world. Reiners (1998) experimented on door lock assembly of car and created a workable application. By using AR author created a real-time fully three-dimensional HMD based application which showed how the door lock can be assembled to the door. Azuma (1997), has done a survey in the field of AR and found out it's area of application, like, Medical, Entertainment, Military, Aircraft Robot path planning, Manufacturing and Repair. Fruend and Matysczok (2002) has suggested that AR has ability to increase the efficiency of the systems.Olwal et al. (2008) has studied how Augmented Reality (AR) can be used to create an intimate integration of process data with the workspace of an industrial CNC (computer numerical control) machine. AR allows operators to combine interactive computer graphics with real objects in a physical environment in the workspace of an industrial lathe. Dini and &Dalle (2015) stated that many experimental approaches have been taken at academic level and at industrial level, like in the fields of maintenance, testing, training etc. They have also suggested that there are still some problems related to hardware and software of AR systems.

Elia et al. (2016) has studied AR applications in manufacturing field by using multi-criteria model based on Analytic Hierarchy Process (AHP) method. Marcinčin et al. (2011) has studied the areas of application of components of augmented reality and highlighted its application in process of assembly. Kato and Billinghurst (1999) have studied about new AR approach and the computer techniques used in various applications of industries. Paelke (2014) stated that user interface factors that are common in industrial

applications and that could make AR more users friendly in future. Nee et al. (2012) discussed various tools and applications of AR in manufacturing and designing. Authors also discussed various challenges related to the interaction between users and AR systems. Ong et al. (2008) stated various that are hindering the successful approach of AR in operations related to manufacturing processes. It also reviews the tools and systems designed for AR applications.Nee &Ong (2013) have reviewed about various studies of applications of AR in manufacturing industries.

Bimber et al. (2000) studied the concept of extended VR by explaining the use of hand-held semitransparent mirror in order to assist AR jobs with back-projection systems. Pentenrieder et al. (2007) studied about AR based applications in industrial planning process. The authors observed that AR helps in optimization of various industrial processes and modification of costs. Doil et al. (2003) have studied the possible merits and explained the development of AR based system in planning process. According to the authors their AR based manufacturing planning system has remarkably improved the inter-communication of user and the virtual planning items. Bottani and Vignali (2018) have presented a review of various papers on AR applications. The authors have observed that most of countries have shown significant interest in the field of AR and its application towards various sectors of industrial application. Tatić andTešić (2017) have presented in their paper a case study about a technique to implement occupational safety in working environment at a universal lathe using AR system and an experiment was conducted in a plant. Gavish et al. (2015) studied about application of augmented reality and virtual reality (VR) for maintenance and assembly in industries. Review has been summarized on bases of application in Table 1.

From review of various research papers and experts opinion author formed a framework of study. Based on this frameworks authors will find application of AR in various sectors.

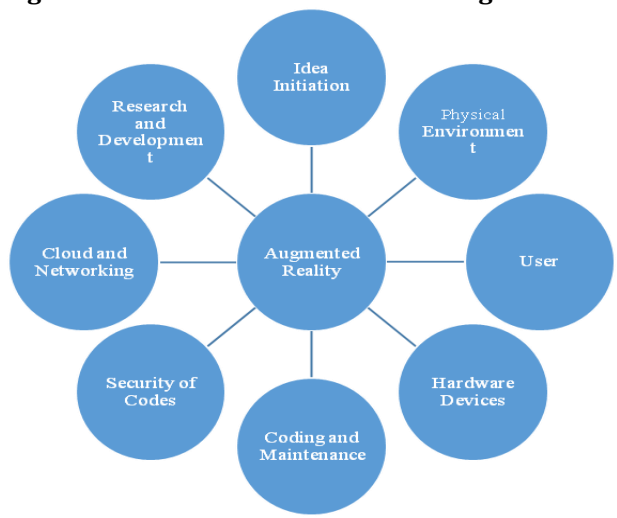
Table 1.Application of AR in different sectors

Sr. No.	Field	Sub-Field	Papers
1	Applications	Maintenance	Neumann and Majoros (1998) Nee &Ong (2013)
		Safety	Tatić and Tešić (2017)
		Manufacturing and Planning	Fruend&Matysczok (2002,Gavish et al. (2015), Pentenrieder et al. (2007), Nee et al. (2012), Marcinčin et al. (2011), Doil et al. (2003), Elia et al.(2016)
2	Experiments		Höllerer et al. (1999), Paelke (2014), Kato and Billinghurst, (1999), Olwal et al. (2008), Bimber et al. (2000), Reiners (1998)
3	Review, Case Study and Survey		Bottani and Vignali (2018), Azuma (1997), Ong et al. (2008), Milgram(1995), Dini&Dalle (2015).

Different elements of AR are:

- **Idea Initiation:** Idea Initiation says, where AR is to be applied and what type of assistance is required for user and what type of arrangement is required for them.
- **Physical Environment:** Physical Environment implies that where the AR technology is to be applied, whether it's is on shop floor, assembly line, training the employees, medical procedures, etc.
- **User:** User is the one who will do the work and get assisted by AR. User will perform all the activities as guided by the AR technology. The user must have skills to be able to work with the components of AR.
- **Hardware Devices:** Hardware Devices implies the instruments that will be used by the user to do any specific task, for example, CCTV camera for surveillance, Head Mounted devices of viewing the objects and accessing the information regarding the objects to work with, sensors that will warn the user if any wrong procedures are followed or to caution the user.

Figure 1. Framework of Elements of Augmented Reality



- **Coding and Maintenance:** Coding will enable the AR technology and will contain instructions about the procedures for doing work and what are the steps that will guide the user to do work. Maintenance is required to overcome any loopholes and flaws in the coding of AR.
- **Network:** It is through network by which the information of the AR will flow. All the information about the object and the procedures for accomplishing the tasks will flow through the networking unit.
- **Research and Development:** No system is 100% efficient, there is always scope for improvement in the system as AR technology is used for assisting the user. So, in order to make the system more user-friendly R&D is also an important element.

3. Applications and Future areas of research in AR

- **Manufacturing**
  Caricato (2014) has analysed and discussed about the role of AR in various manufacturing sectors, such as, design of model and layout of plant, optimization of assembly process, planning and designing of production processes and maintenance and services.
- **Supply Chain Management**
  Cirulis and Ginters (2013) studied how AR can reduce the human errors and improve the working efficiency of human during packing, handling of items and decision-making. Authors also discussed about the potential of AR in logistics. Glockner et al. (2014) discussed about the role of AR in logistics. According to the author AR can help in operations related to warehouse, reduce transportation time and improve the quality of services.AR can find application in the Humanitarian Supply Chain Management (HSCM), by the help of this technology the HSCM company can keep a track record of which type of items are to be delivered in which specific area and what is the quality and status of the products that are to be delivered.
- **Education**
  Lee (2012) discusses about the role of AR in education. According to the author AR can assist the teachers for explaining topics of various subjects like chemical bonding in chemistry, study of human body in biology, study of astronomy by projecting 3D images of celestial bodies and geometry modelling education in mathematics.
  AR can be used in making library working more smart and efficient. By the application of AR book searching time can be reduced. The shelves of library may contain a reader (QR or Barcode reader) that would contain information regarding the positioning and number of books in each shelf. AR glasses or HMD which may contain scanners can read these codes and can give position of the required books in real time.
- **Construction of buildings and bridges**
  Shirazi and Behzadan (2014) and Khalid et al. ( )have discussed about the use of AR in 3D modelling and construction. AR can also assist users in construction of buildings and brides. There are simulation software that can assist the engineers about the various stresses analysis and loading

condition. AR further can show stress and loadings in real conditions. Any alteration required for aesthetic purpose or for any modification in design can also be achieved through AR. Positing of electric wirings and water pipelines pre/post constructions of buildings can also be guided by AR in order to alter or do maintenance. Optimization of head losses in pipe line design and the analysis can be done by using AR.

- **Colouring and decoration of House/Office halls**
  AR can also help the users for choosing the type of colours they want on walls of house/office. Also, they can use AR for selecting the type of design for ceiling and flooring. The type of curtains and furniture and their placements or arrangements they want.
- **Medical Procedures**
  Technology has helped doctors for performing various medical procedures and diagnosis of human or animal body. However, AR can also help the doctors for performing medical procedures as well. For example, while performing operation of lower spine, the doctors have to take care of nerves of that particular area. AR can assist them by highlighting the nerves and also assisting they while various operations and especially the surgeon in training stage.
- **Military**
  Livingston et al. ( ) discussed various applications of AR in military. AR can give information about the terrain to the military personal in order to plan them for performing surprise attack or surveillance. Also, after they get information from the battle field about the situation, AR can help military about the type of ammunition the regiment had to face and what type of ammunition are best suitable to tackle them. AR can also guide them to analysis the terrain of their respective regions.
  Similarly, AR can also play a vital role for bomb diffusing squad. While diffusing the bomb, the HMD of AR can give best optimum technique for diffusing the bomb as soon as possible.

4. Conclusion

Augmented reality is a technology of future. It finds application in almost all sectors such as manufacturing, maintenance, medical, aerospace, education, SCM and military etc. In this paper authors developed a framework by taking different elements of AR by review of different research papers and experts opinion. Different applications from different fields are discussed in current paper. Current observations on AR by authors have different implications in academia and industry. The authors are currently working on developing a framework on application of AR in manufacturing and supply chain management sectors. Authors will further analyse the finding by multiple case study in Indian scenario in various industries as future course of research in current area of AR.

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