Virtual and Augmented Reality in Construction Field

Master Thesis

International Master of Science in Construction and Real Estate Management

Joint Study Programme of Metropolia UAS and HTW Berlin

from

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Metropolia

Hochschule für Technik und Wirtschaft Berlin
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Conceptual Formulation

Master Thesis for Mr. Mohamed **Hisham Mohamed Tohami Abdelaziz**

Student number: **s0567918**

Topic: Virtual and Augmented Reality in the Construction Field

Undoubtedly, applying virtual reality in market has become rapidly increased, it needs to be exploited in the construction field and technology related to designing models in order to enhance framework pattern which intervenes in financial phases too, the research methodology includes theoretical subjects and case study that supported incorporate with a company engaged in simulating infrastructure projects.

Objectives:

•Design effectiveness using virtual reality

•The concept of VR and the difference between MR and AR.

•Improving successful control in planning and financial phases- the ability to test several factors without the time and cost of building the structure

•Successful control of construction project management.

•Improvement the sense of realism with haptic feedback of VR, AR instruments that strengthen the client-company connection.

Problems statement:

•Importance of technology usages to minimize losses and crises during the implementation.

•Low rate of advancements in technology and using steady concepts which constraints in work plan.

Research question:

•What could VR, MR and AR influence into supplies (income labours, cost, project duration)?

•How can the project be simulated with AR/ VR and the foreseen presumption for the project timeline?

•what is/are the relationship(s) between BIM and AR/VR and to what extent can BIM and AR/VR be integrated using platforms to earn benefits? (IRIS VR, ..etc)

Signature of the Supervisor (11.07.2019)
Sunil Suwal
Lecturer, Metropolia University of Applied Sciences

Abstract

In this research, I would like to introduce one of the most exciting developments in technology and the way to develop in the field of construction by using Virtual Reality. At some points, the augmented reality takes place to make better in management, quality control, and preventing clashes between designers. In addition to integrating into BIM with (AR / VR), improving the user experiences by immersing in the virtual world provides more intuitive infotainment system, less budget.

Contemporary virtual and augmented reality systems provide many possibilities for adoption in different industries, the technology can use in Architecture, Engineering and Construction (AEC) industry, that is one aspect is included in this research. Furthermore, some explanation about the project, cost, and quality management, also the usage of devices and technologies in digital workbench which will be sent directly from the site to the office neglecting the time of effort in delivering reports. After this, the third chapter is covering the BIM- VR involvement and type of management, also including augmented reality management besides the key features come out of this result.

It represents an important topic to study because of providing a way to save cost, increase construction safety and raise the profit rate. All features fetched form augmented, and virtual reality is coming by one prompt as a summary of many complicated processes that usually managers struggle. Moreover, following visual -real process can break down all complexities and difficulties across implementation depending on how complexity is the project and time-related constraint, the AEC firms utilize either develop the walk-through in-site that is coming in the early construction stage.

Eventually, two case studies would take place by using Revit structure, 3D Unity, C Sharp program, and some features that frequently arranged to have the resilience of project processes. Both case studies are pointed out with VR/AR displayers to feel the reality in the project.

Key words: Virtual reality, Augmented reality, project management, Unity 3D, C sharp

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List of Abbreviations

2D	2-Dimension
3D	3-Dimension
4D	4-Dimension
5D	5-Dimension
AEC	Architecture, Engineering, And Construction
ANSI	American National Standards Institute
AR	Augmented Reality
BIM	Building Information Modelling
BSNS	Business Social Networking Services
CAD	Computer-Aided Design
CEET	Construction Engineering Education and Training
CIBO	Chartered Institute of Building
CPM	Critical Path Method
CS	Construction Safety
DM	Defect Management
DPR	Division of Professional Regulation
EH&S	Environmental Health and Safety
FM	Facility Management
FOV	Field of View
fps	Frames Per Second
GIS	Geographic Information System
HMD	Head Mounted Display
ICML	International Conference on Machine Learning.
IDE	Integrated Development Environment

IFC	International Foundation Class
MEP	Mechanical, Electrical and Plumbing
MIS	Manufacturing Information Technology
MR	Mixed Reality
MS	Microsoft
NASA	National Aeronautics and Space Administration
PDM	Precedence Path Method
PM	Project Management
PNG	Portable Network Graphic
PS4	PlayStation 4
QA	Quality Assurance
QC	Quality Control
RC	Reinforced concrete
RFI	Request for Information
RFT	Rich Text Format
RII	Risk Identification Interface
S&H	Safety and Healthy
SEGA	Sega Games
STS	Safety Training Simulation
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
VA	Visual Assembly
VPL	Visual Process Language
VR	Virtual Reality
VS	Visual Studio

WLAN	Wireless Local Network
XR	X-Ray

1. Introduction

This research helps to set up a theoretical and practical basis of Virtual-Augmented Reality principles in terms of construction field, moreover, this research is to offer detailed guidance on recent and upcoming developments in revolutionary manipulation systems; in particular, its important components, such as virtual reality and unmanned vehicles, Augmented reality and 4D BIM integration and the AEC involvement.

Visualization is needed to fulfill the planning requirement especially, in project complexity along the time which is reducing the cost/time of construction, maintenance, in-creasing in construction safety and pursuing client satisfaction with visual appearance as much similar as it previews on case studies chapter six.

The methodology and technique chapter is describing the linkage between BIM and visual programs, also, the four-dimensional projects in the immersive and non-immersive pattern, furthermore, this chapter is preparing to let the reader understand the management types section which provides the high benefit of using this technology in the construction field, also this chapter is preparing to know what type of software's have been used in the case studied chapter. The project managers and participant members are seeking for a way to shorten the project period and increase in production rate, in this report, it focuses on the management acquisition and the functionality comes out from visual platforms.

The research carried out two case studies one focus on Augmented reality platform of a WEDO project contains a residential building with BIM modelled located in territory desert in Egypt, beside of previewing the building in VR mode with able to segregate building layers, and the other case study is a roller coaster in China with using BIM model and laser scanner technology then integrating all models to have in result some benefits of using VR mode in this project.

Furthermore, it has been added the model to the Unity 3D and Visual Studio to pull out the provision of AR mode to appeal the quirky features that most important to know when testing the roller coaster virtually before setting up the construction parts.

1.1 Overview

While there are various philosophical views and discussions on what the real world is (is our existence just illusion and thus simulated like every other, we will use real reality in this paper to describe the 'true' world in which we reside. It is something we can feel with our five senses.

Virtual and Augmented realities become highly present in the business environment and exponentially increasing in rate of construction field has become controversial. However, these points are highlighting which concerns on VR, AR or MR in construction premises and industry. Nowadays, commercial buildings are applying this technology to their projects in different scenarios to ease the way of implementation for a residential property.

This research shows the modern management in the construction field in dealing with complex products and the way of visualization, also the feature of using virtual reality and affections between a company and client, and that would show with the example of DPR project.

Moreover, safety is playing a significant crucial for hazardous prevention, and ensuring the project is processing seamlessly with well-organized safe way. One of the goals is to persuade company how visualizing solution can affect to the company management; an example of companies that affected before and after intensifying in visual programming. Thus, improving in sectional improvement. It talks about VR capability, particularly in linkage to BIM programmes easily by giving an example in case studies (Zorica A. Dodevska, 2018).

Furthermore, Bad teaching way leads to over half the accidents at work. It is the safety nuts-bolts of building and teaching way is increasing awareness. The research has found a relation between the construction industry's standards and the health conception status which is one point included in the research (Li, 2018).

1.2 Investigative questions

The coming up questions are the goals of what the research is carried out, mostly, what benefit in the domain of virtuality and here are the most questionnaire which covers in this report:

- What is the possibility to influence the rate of the company's budget by using a visualization technique?
- How could it be useful in marketing?
- How can Virtual reality impacts on real estate?
- What could VR, and AR influence into supplies (income labours, cost, project duration)?
- How can the project be simulated in AR mode and the foreseen presumption for the project timeline?
- What is/are the relationship(s) between BIM and VR and to what extent can BIM and VR be integrated using platforms to earn benefits? Research methodology study design?

1.3 Research methodology study design

It encompasses analysis in two sequence scenarios:

- Analyzing the consequences of UAV's and DPR project highlighting related parts of the topic
- Analyzing two case studies using 5D-BIM model, one has made by the Author.
    - Case Study: BIM involvement with Virtual Augmented Reality.
    - Case Study of Project of 3D BIM Roller Coaster in Iceberg.

2. Computer and Visualization

2.1 Definition

There are too many definitions of visualisation but typically communicate visual data or transformation of raw data into insights which make readers easily interpreting or extracting data from the IT structure underlying it. In general, this data is in the form of figures, estimates and overall operation. The data analyzed by using tools for visualization and displayed on the dashboard of the device.

A growing number of companies seek to organize and develop their quality control, the organizational structure, policies, processes, and resources required to handle the company's quality aspects, and these are a quality framework.

Visualisation is the most valuable method for designing and assessing products as well as work environments in the design process. Use drawings, 3D images and animations will promote definition and analysis in the designing and evaluation of potential production processes. Instead of actual designs and mock-ups, time can be saved by using visualisation.

Visualization can make:

- The usage could save time instead of mock-ups and physical prototypes
- Improving collaboration between users and designers and help the stages of design and understand future assembly work planned.
- Visualization has also proven useful when designing a new plan model. 3D-dimensional photos and animations can be used to imagine the plan layout and output flows inside the plan and thus help to develop a shared language among employees.

2.2 Visualization and Reality

Visualization term is the opposite of realization which is non-visual datum comes for the purpose to summarize indirectly visible objects by producing images which close to the reality or might not aim, it depends on the process succeed. In result, it must be recognized for what user-perceived (Merriam-Website, 2020a).

Reality is something exist not derivative and occurs afront of our eyes and it does have space usually in real life (Merriam-Website, 2020b).

The building is a high-risk industry that entails several potentially harmful factors for workers. Most construction firms have always promoted health and worked hard to ensure that their workers are out of dangerous, accidents, and injuries.

Since the emergence of VR, AR, and MR, there has been an observed movement to capitalize on developed immersive Virtual and augmented reality technologies to build accommodating environments for the simulation of challenging organizational scenarios, the creation of risk-preventive awareness and the training.

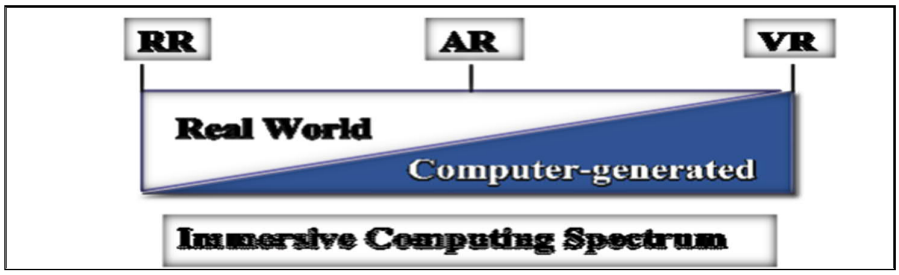

Fig. 1: RR, AR, and VR. Source: (Zorica A. Dodevska, 2018).

AR and VR are different technology and visualization scenario and this research starts with a study and synthesis of evidence for various VR / AR implementations, products and the associated training and assessment paradigms to make a person well understand the art state of Virtual/Augmented Reality apps in terms of a construction safety (VR / AR-CS) and from which to discover the relevant issues and suggest potential developments.

In the field of construction management engineering, Augmented Reality and Virtual Reality are used by putting a 3D model to the user's front view, consultant and contractor's eyes by starting an experience of learning unlike any previously seen (C.S. Park et al, 2013).

In this way, it helps a person to engage with real-world projects, solves hardships and risks and accidents prior it occurs basically, this what is part of the research. The reality classified into many types, but in this research, we are going to focus on AR, AR.

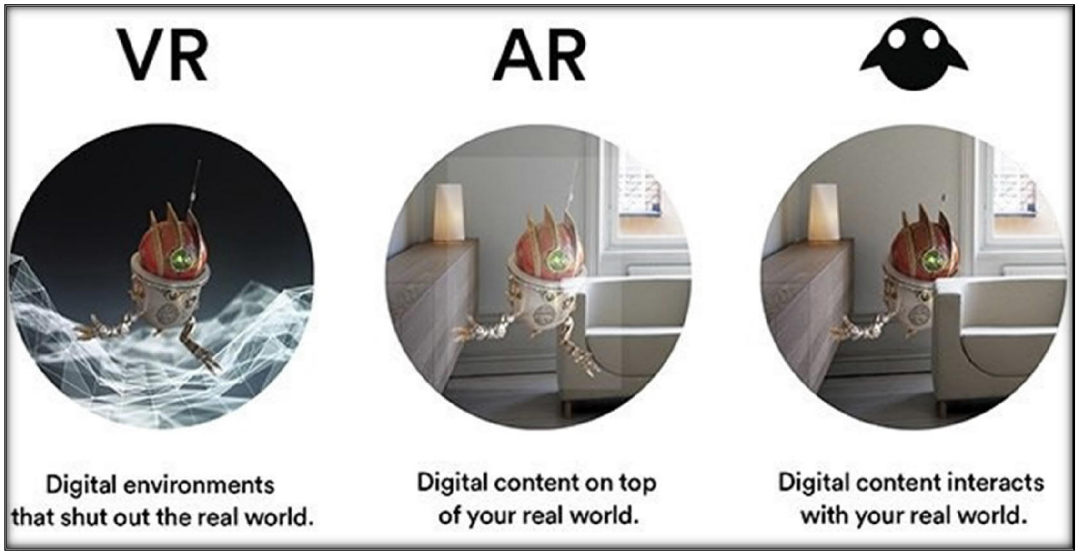

Fig. 2: The 3 different realities of visualization. Source: (Valendu, 2018).

2.3 Visualization and scheduling

There are several methods to schedule activities in the project, the major methods are Repetitive Schedule Method, Scheduling Model, and Critical Path Method (CPM), the first two methods are approaching graphically, whereas, CPM is approaching by math which merges activities processing without counting the multitude of activities modified.

The main idea of using applications and programmes like Autodesk software's (Revit, CAD) in construction is to visualize and synchronize the construction work with scheduling and utilize the process of visualization.

Integrating all together to work alongside is called 4D tools (3D model + Scheduling) - usually it schedules by Gantt programme- and this is describing in detail in management chapter, both can be developed within GIS which utilizes the database management possibility to sustain the construction supplement datum to serve the planning domain.

Whilst migrating raw data in the format of GIS, it happens in two ways, eighter digitizing GIS image file and convert it to a vector file or importing CAD drawing and shape it then make extrusion to the model (Abdelhameed, 2013).

2.4 Augmented Reality

2.4.1 Definition

Augmented Reality (AR) is a concept that allows streamlining the process of enriching a computer-generated view of the physical world with digital elements and to preview a live indirect or direct seen of a physical environment. Usually, the "augmentation" of reality carried out in real-time and in conceptual harmony with the real world experienced.

The data added mainly represents a multimedia extension of the observer's senses. Several research groups are working on projects and making simulation systems that include AR components used in various fields such as city navigation, renovation, entertainment, rehabilitation, and video monitoring (Aleksander Nawrat, 2016).

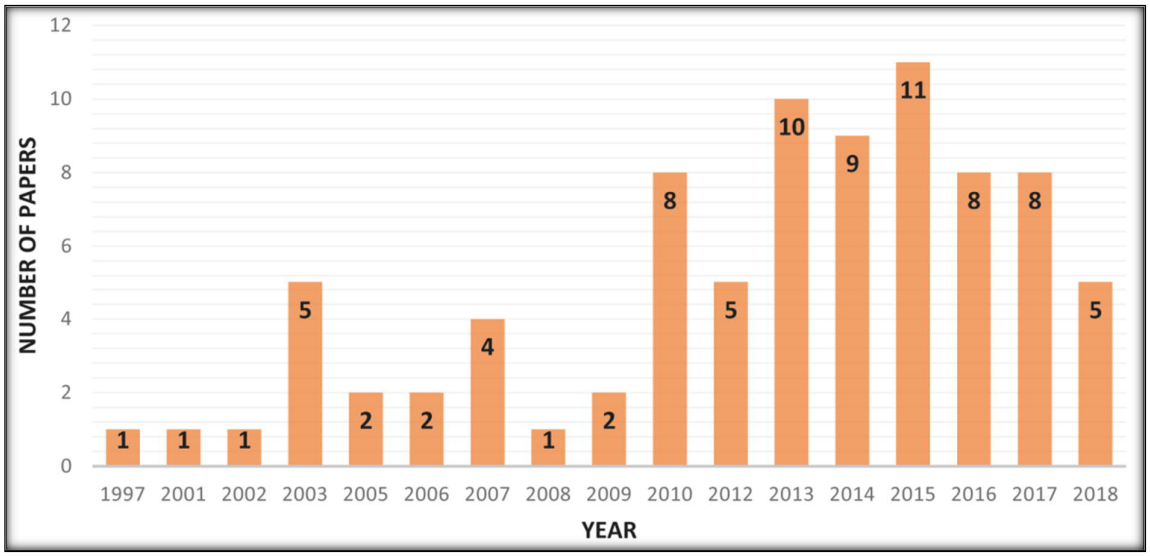

Fig. 3: Annually number of check out publications. Adapted from (Ahmed, Shakil, 2019).

Augmented reality is sort of immersive, the reality-based view device that utilizes functionality from the image, text, sounds and effects created by the computer to enhance user experience in the real world (Zorica A. Dodevska, 2018).

Human vision is limited to only monitoring seven elements at the same time in maximum concentration. AR can be replaced to develop the digital -humans work together, AR universal market expected to reach 90 billion dollars in 2020 (Stannard, 2019).

2.4.2 AR in construcion field

Augmented Reality is used at different building project stages and divisions. It is the most obvious stuff to introduce in the project of relating construction to put the automation into the design. By using advanced tools, sensors, and cameras, it helps in construction field to model, drive, and schedule the project efficiently and accurately. Also, improving safety, managing cost, and simplifying collaboration, it can measure the height, depth, and width of physical properties, briefly, the space is recognized while using the AR platform (Stannard, 2019).

The best option tracking and detecting the construction project is using AR on tablet, PC or mobile, this will make an estimation for work on-site according to the suggested schedule of the phase (Sebastjan Meža, Žiga Turk, Matevž Dolenc, 2015).

The use of AR for building project stages monitoring as a path of construction project progress with schedule, as seen in the case study section. The AR technologies easy to present a visual comparison between the designed facilities and the as-built facilities. Briefly, augmented reality is one of the most widely used features of advanced development projects (C.S. Park et al, 2013).

Building infrastructure worksite planning involves building worksite design as well as resource management optimization. Construction projects often require a limited span, which requires a quick and versatile planning approach for construction worksites. Current worksite layout design relies heavily on 2D paper media where designers draw the potential worksite layout parallel to their real world.

AR technology core areas of application include in AEC, BIM, update publics Land correspondence, maintenance, medical and pharmaceutical cultural heritage (archaeological sites, museums) entertainment and travel. This conventional strategy turns out to be inefficient and error prone since only skilled and good trained designers can produce productive construction model design in paper scratch. That often requires a long period of learning and training to approach an appropriate expertise level (Wang, 2006).

2.4.3 AR and UAV aircraft

It is an aircraft driven by no human pilot named as Unmanned Aerial Vehicles (UAVs), the vehicle is operated either autonomously on its own by microprocessors or by operators using a ground station under the telemetry control. In table 1 shows the typical application of UAV (Ming-Chang Wen, 2014).

Unmanned aircraft	Control system	Telecommunication	Other equipment and mechanics
Fixed-wing aircraft exist, and rotorcraft rely on the lift method of the aircraft.	The Aircraft and ground station flight master.	Systems also use different radio frequencies to transmit data.	Those include “laser rangefinder and camera gimbal stabilization”

Table 1: Type of UAV application[1]

UAVs are increasingly using cameras to observe the environment to enable surveillance and monitoring of specific areas. These cameras used for video sharing and algorithms for overcoming obstacles. Algorithms are preventing snags and avoiding collisions are commonly used by many organization companies thus, these algorithms are a key feature of unmanned aviation (Ming-Chang Wen, 2014).

AR refers to “the technology that connects elements which are supplemented by computer-generated sensory data, like graphics or videos to a real scene of real environment event”. The civil and defence industries are using UAV widely these days, and some features which important in construction management by using UAV, such as:

- Site spatial elevation transmission: by using RFT that particularly enhance the image transmission by taking into consideration the magnitude of the construction site.
- Finding overlooked design problems on what is in the construction site, such as vehicle track planning disputes and spatial dilemmas structure.

„In future, many construction companies plan to examine the UAV-AR solution in three common scenarios for the construction“: standard construction site, an inspection of the bridge, and urban planning (Ming-Chang Wen, 2014).

[1] In conformity with Ming-Chang Wen, 2014 p.1750.

2.4.3.1 Implementation in AR mode

To use augmented reality development, people commonly use Unity 3D, and the extension Vuforia engine to view by the apparatus or remote control. suits to platforms like android, PC, WebGL, ios, Apple tv tvOS, Xbox One, PS4, and many more platforms contemporary to our modern life.

When the camera which mounted on UAV recognized a goal, it generates experiences of augmented reality, introducing new features and content built. We use this to blend the scenes between actual and virtual views. A 3D building renders a real-time layer on the image stream.

To improve on-site surveillance usability and efficiency, we want to create a telecommunication network for multiple users to display concurrently the same picture source. We applied the method of WLAN transmission to transmit the image stream to multiple views in all different angles.

Also, enabling any devices - whether a smartphone, computer, or tablet- hold by professionals like Engineers, Architects, managers to track and control to access and share their views on the stream.

2.4.3.2 Multiple devices using one WLAN system

To let anyone easily accessing the image stream, it needs IP cameras so that would optimize the efficiency of different systems.

Build more possibilities for using the image stream, such as monitoring and other image processing technologies, In figure (4) shows the idea of applying AR on the view stream from UAV or what so-called UAV-AR (Ming-Chang Wen, 2014).

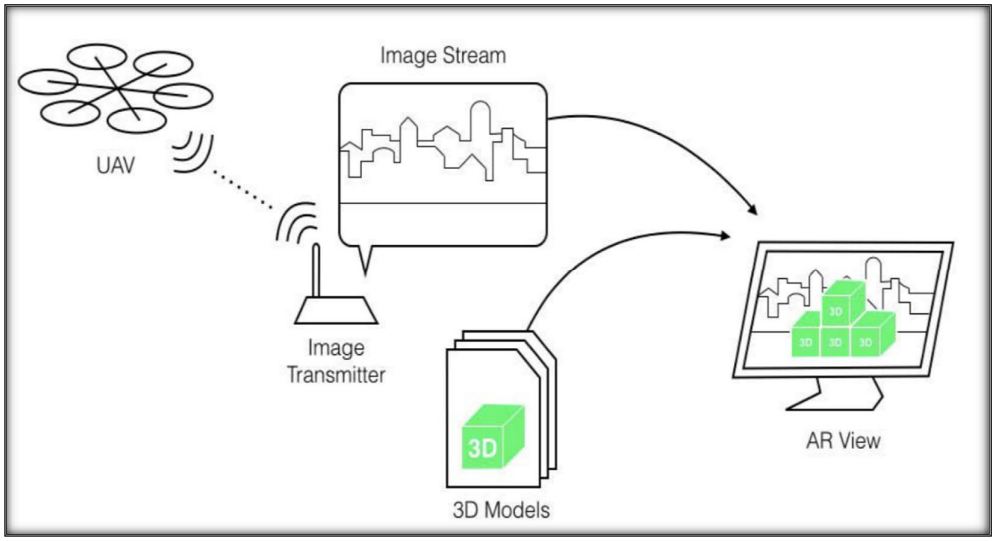

Fig. 4: AR on view stream from UAV. Adapted from (Ming-Chang Wen, 2014).

2.4.3.3 Technique

Testing a field using UAV-AR solution on construction site and that is going by steps:

1. Flying and capturing on the plan view of the site and shooting the entire site view with a camera pointing perpendicularly down to the ground.
2. After scanning procedure, the USV is sending images to the transmitter at the station and storing all data which has been captured for Vuforia and imported to 3D model to bring out the features and mix the virtual with the real environmental perspective then create the AR view. When the computational process is complete, we can take off and preview the AR mode.
3. Lastly, we link the image stream output via wireless local area network and a 32-inch LCD monitor to provide two field viewing options. In figure (5) shows the integration part.

Fig. 5: Two monitors presenting one AR view. Adapted from (Ming-Chang Wen, 2014).

2.4.4 Planning the virtual construction worksite

The design process usually includes several parties (foreman, worksite layout planner, building managers, foreman, construction, superintendents, staff, etc.) from the construction company's various departments/trades.

Due to the lack of successful ocular representation implicit in a conventional paper media, coordination between parties of different levels cannot be well advocated when it is coming to participate in the planning process. By having a two-dimensional sketch paper, the consumer did not get the spatial impression (Wang, 2006).

Fig. 6: AR toolkit shows the proposed infrastructure. Adapted from (BRADLEY, 2014).

In the brain of humans, the spatial 3D perception of the whole designed view must be created mentally. Furthermore, the approach cannot adequately depict the planning rationale - e.g. description of the engaged areas and stability margins- that would otherwise improve the reliability of design to be even greater degree.

The 2-D sketch did not provide any sense of immersion, the users spatial meaning is not well-recognized. Therefore, the number of errors increases throughout the planning process. To meet the needs of all these parties planning and implementation, a more collaborative tool / platform for collaboration and visualization is needed to promote effective coordination and collaboration.

AR technology provides a new approach to the problems noted, it may create an atmosphere in which computer-generated additional information incorporated into the user's view of a real-world scenario. AR technology ultimately enhances the understanding of human being as a real-world individual by introducing specific digital knowledge into the physical environment.

Fig. 7: Visualize parcels in urban city. Source: (Intertisement, 2020).

Augmented reality makes the user operates in a real-world environment during providing additional computer-generated or modelled information visually to support the function. In the past, virtual reality worlds mainly use in scientific simulation and gaming entertainment. It has studied in recent years for purpose- human activities, such as training, collaborative study, and surgical operation.

AR applications have applied in various industrial enterprises, such as assembly, quality assurance, industrial maintenance. The significant advantage of the AR tool could provide easy setup for construction worksite planners where even unqualified novices could track the whole intelligent factors.

By using creative, lightweight, and affordable interaction with display tools, the AR interface allows users to digitally intensify the vision in a new reality that is amplified by knowledge created by computers.

2.4.4.1 Related works on AR

AR technology intended to enhance the existing state-of-the-art simulation of the architecture, design processes, management systems and construction processes for engineering.

The design and construction industries require the production of large volumes of data and knowledge that multiple parties need to access in several locations under various

obligations. Pursue better training operation and accessing to large amounts of engineering and management knowledge in the construction industry create conditions which allow the most promising use of AR techniques by involving construction workers in the expanded workspace.

2.4.4.2 Communication and processing of data

By having the efficient connection and data processing from the construction site, a great potential to make a construction project success is underlying. Access to on-site project knowledge and efficient communication was greatly improved by the implementation of various Augmented Reality technologies as opposed to more conventional sources of information (Wang, 2006).

2.4.4.3 Monitoring and documenting in construction site

Automated reporting and tracking are a crucial subject for the construction industry. It may facilitate monitoring of the achievements of contractors, as well as the identification of schedule derivations or the hunt for sources of defects and the employees responsible. The last point is especially important in terms of expectations and obligations for compensation. Adequate mechanisms for tracking progress help managers and staff track the status of the construction work as well as identify the root causes of defects. Construction site workers nowadays frequently use digital photography to record the progress of a construction site. Usually, team members frequently take individual photographs of the construction site and store them in a database along with the plans for the construction site.

The picture sequence depicts various stages of progress in construction. It can be difficult to evaluate this knowledge and to search for sources of error. Additionally, translating the 2D camera image details into the real physical 3D environment is tedious to the user. It helps managers to link possible mistakes or bottlenecks to times, and to classify the responsible staff. The downside of this method is that the images must be taken manually by a member of staff (Zollmann, 2014).

2.5 Virtual Reality

2.5.1 Definition and history

The Virtual reality term is taken from both single terms of this combined word, the reality is the experience of life in real and the virtual is what close to this real, actually the term might be close reality as well. The reason for using VR is that if anyone can preview his information-based realization.

Virtual reality is a technology that has been seen as a natural progression of advanced sensors to 3d visualization. Only recently this technology has evolved enough to merit engineering design applications. The convergence of this new technology with manufacturing software, engineering, and design systems would provide a new boost to the computer-aided engineering market. One area of manufacturing and production that is theoretically greatly influenced by virtual reality is assembly production.

The understanding of reality also changes in response to it, this presenting is not real but perceived that in his perspective. It relies on special instruments such as VR headset, goggles, and gripper or convoy sensor leapers (gloves), besides, it uses in showing the history of the old era like archaeology and dinosaur science.

The history of VR is describing next page at along the time it incepted and the time in devoting through the improvement of the technology in efficiency and effectiveness.

Fig. 8: Types of VR goggles.

The stereoscope invented in 1838. Charles Wheatstone conducted research which showed that the processes in the human mind it as a single three-dimensional image when each eye faced with a 2D image. Stereoscopic photographs of famous touristic destinations were displayed along together and viewed through the stereoscope to make the impression of immersion. Those same ideas are used today in VR screens mounted on mobile phones, such as Google Cardboard.

In 1961 Comeau and Bryan, two Philco Corporation engineers-built Head sight. The head sight was the first HMD to control motion. For each eye, it had built-in video screens and a head-tracking device. See figure (8).

However, it was not specialized for virtual reality; it was developed for the military to allow them to keep solders away from dangerous situations with a safe distance. A remote camera imitated the head movements so that the user could look around the setup (Minessale, 2018).

The Sensorama established next and patented in 1962. An arcade-style theatre was invented by Cinematographer Morton Heilig, which one interactive movie theatre is showing all activation of senses. His target was to let the audience feel a filming mode was using stereoscopic 3-D pictures, stereo speakers, fans, and a vibrating chair. He

also developed the Tele sphere Mask and was the first VR equipment to be head mounted. Inspired by the Tele sphere Mask, in 1968 Ivan Sutherland created the ultimate head-mounted tool ominously called Damocles Sword.

Instead of a camera, this device was connected to the pc which caused it too big to sit on a man's head and had to hang from the ceiling. The headset displayed 3D created by computer that changed perspective when the user rotated their head. Myron Krueger was the first to use the word Artificial Reality in the 1970s. In the 1980s, the computer scientist Jaron Lanier later used virtual reality, the term we now know and love.

In 1989 and After obtaining a contract from NASA to create the audio portion of the Virtual Environment Workstation Project (VIEW), Scott Foster created Crystal River Engineering Inc.-a VR simulation simulator for astronauts. This company developed real-time binaural 3D audio processing, a view of this in figure (9).

Mattel, Inc has launched the Power Glove, based on DataGlove from VPL. The Power Glove was an accessory for the Nintendo Entertainment System controller, but it never took off because it was difficult to use it (BARNARD, 2019).

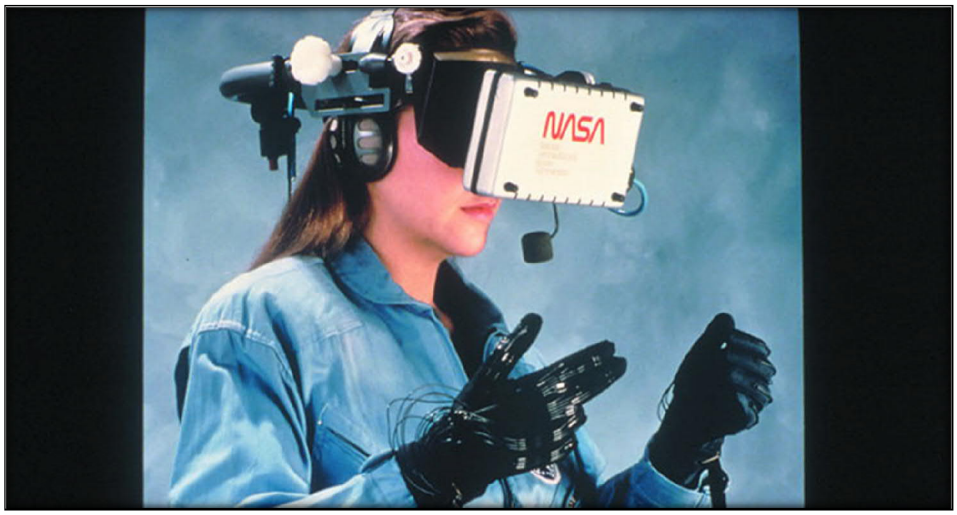

Fig. 9: VPL power gloves in NASA. Source: (BARNARD, 2019).

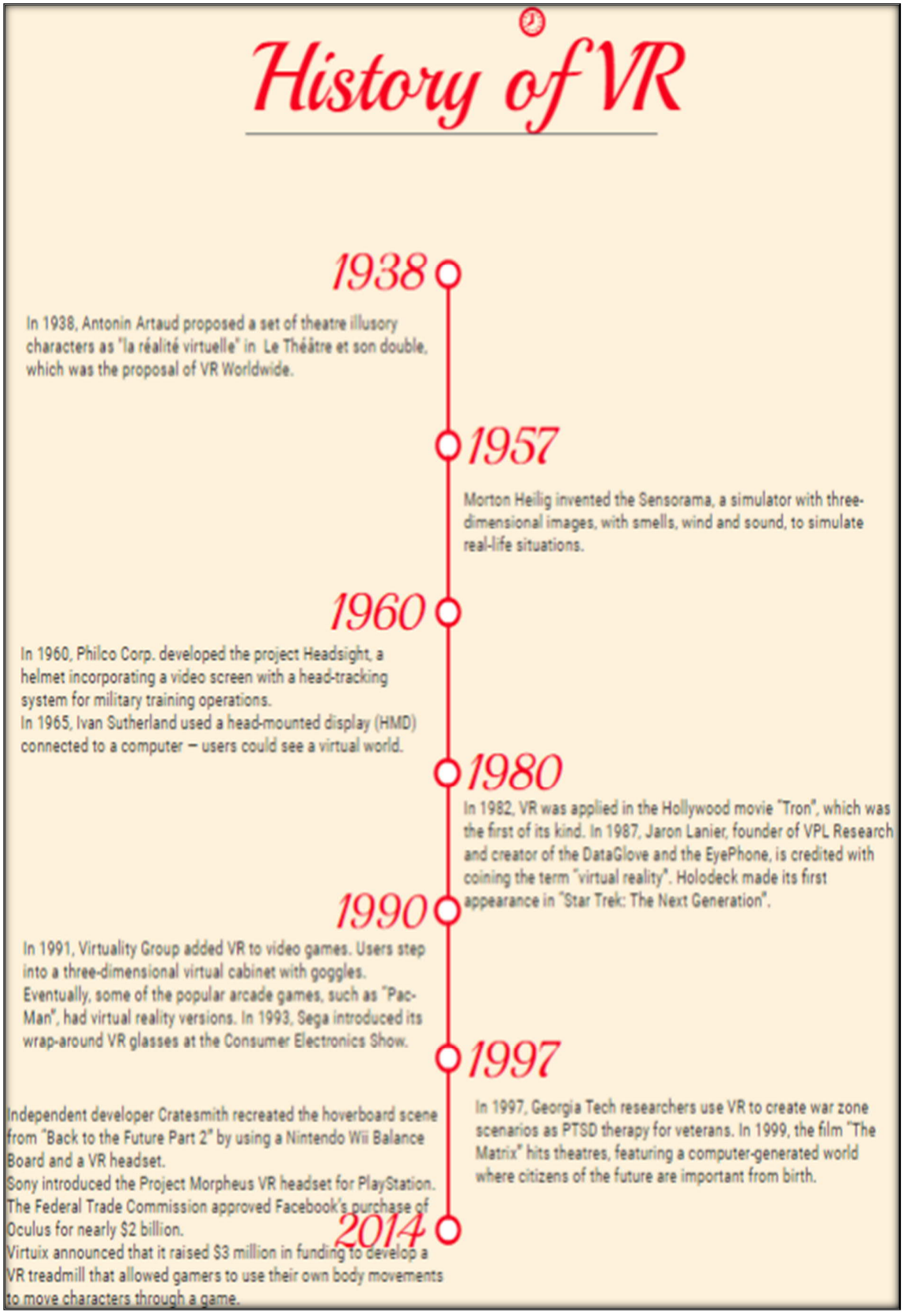

Fig. 10: The history of VR. Adapted from (Li, 2018).

In 1991, Lanier also dedicated his life in VR modelling equipment's, such as goggles and sense cloves. (Virtual Reality) describes it as an inherently dramatic medium, acknowledging the difficulty of converting a first-person solo and subjective VR experience. The first VR gaming released by Sega company developed for their 16-bit Game console for Genesis.

The headset was sadly never released to the public because Sega was worried that its VR would be outstanding, in the real world, people would apply that to likely end up hurting themselves by accident. Recent reports tell us that the headset has been having too many technical problems. And in 1994 SEGA launched SEGA VR-1, a machine simulates motional.

Fig. 11: SEGA video games in VR mode. Adapted from (BARNARD, 2019).

In 1995 Nintendo and the Nintendo Virtual Boy tried their hand at VR. Although buyers were excited about this product's portability, an uncomfortable fit and unimpressive visual rapidly turned the headset into a flop.

Nowadays, increasing excitement in user viewpoint about smartphone because of innovations and the jump in graphics efficiency have made more demand for VR once again. Google cardboard, tools related VR, and its headsets enable everyone with a smartphone (which is almost everyone nowadays) to take part in the phenomenon. And engineers are beginning to make special VR treadmills, so you will not crash into the wall of the living room or slap the television, the future of XR is only a beginning with a controller when the 5th generation launched in the next year and increasing the gaming community (Minessale, 2018).

The active number of virtual reality users worldwide from 2014 to 2018 was as shown in the table below:

Type and Year	Approximate Early Majority	Early Adapters (Light Gamers)	Innovators (The Gamers of Hardcore)
2015	7	3	0.1
2016	30	13	7
2017	60	20	17
2018	110	40	25

Table 2: Number of active VR users worldwide from 2014-2018[2]

Google company has established recently google VR platform, which branches business to apply for all different kind of field and improve it in a way that amuses the user while he makes the required daily job, as wisdom said ‘’if your work is sort of what you usually make it in leisure time, it will not work anymore’’, this goes straight to good work result and precise workflow, their job to include virtual reality to allow users see the visual environment as in the real environment.

Augmented Reality	Virtual Reality
Digital and real-world integration	The completely artificial digital world.
User experience is immersed proportionally	Complete immersive sense.

Table 3: Differentiation in AR and VR[3]

2.5.2 VR in the AEC industry

AEC is a construction industry sector forms facility on architectural planning, engineering planning, and construction works. A 3D model-based method hands the AEC experts to effectively plan architectural building design, execution, and service standards.

In the situation of current Coronavirus pandemic, most industries have been influenced to lockdown the crucial projects, with compliance to the social distancing and governmental mandates.

Nowadays, the technology of VR uses in an integrated building sector department. These uses as a significant method for training of employees, the safety management

[2] In conformity with Haggard, 2018 p. 26.
[3] In conformity with Li, 2018 p. 21.

system, progress monitoring, labour prevention, prevention of defects, etc. (Ahmed, Shakil, 2019).

On the other hand, the construction institution and design companies are probably unaffecting directly by the pandemic that influents to a stoppage in execution sectors with following to guidance and directives taken from organization management of the construction company.

In AEC companies, employees were used to be working quarantined and remotely at home, despite that, the rate of the standard solution for what is coming from analysis, project management, virtual reality, etc. is still growing steadily.

Also, expecting to increase in acceleration, AEC firms are interactive with many companies are highly demanding these days of quarantined time like online shopping firms where need warehouses for their companies like Amazon. Therefore, industry unlikely to have any sudden impact.

Meanwhile, the pandemic spread worldwide, in result, as many programmes have offered free access to let AEC technology companies proceed forward, these offers like:

- Offering by Autodesk for accessing the cloud collaboration products (BIM 360-Docs, Design, AutoCAD Mobile and Web).
- Solving any issue coming from the difficulty of dealing with GRAPHISOFT licenses at home in the name of contingency license, in addition to giving 60 days trail.
- Also, Abvent is offering the same contingency license and the same as GRAPHISOFT.
- Free entry from Bluebeam to Revu solving problems for modification and PDF editing (Khemlani, 2019).

The development of interactive content includes a variety of specialities. An ideal improvement, many parts participate in a project:

- The first role to the designers who determine the proper application to go through it. Beside finding which is the best tools to use to have a good achievement in the result.
- The outcome is revised by the programmers who are codifying the needs to create. We create other things through the coding language, such as interaction,

graphics, physics, or network. The programmer uses his language in coding to determine his specialities, and the language mainly used by the software.

- Role number three is the users who devises the application's visual aspects. The design of the object, interface, setting, and visual presentation is assigned to this function. The artist may use many approaches in designing these aspects, such as hand painting, digital painting, or sculpting. Often, artists model the tools that should be used in interaction (I. Mutis, 2019).

AR/VR aspect	AR/VR application
Architecture, civil engineering, construction, and real estate	Instead of traditional 2D drawing and modeling style, businesses and companies will now witness a realistic image of their potential homes, apartments, business sites, both from the outside as well as from inside. The implementation of AR / VR technologies in such projects substantially reduces costs and time spent, enhances design, and promotes the planning of the building. There is also a research that composes current VR / AR applications from the point of view of building safety with the conclusion that AR / VR applications have already accomplished a lot in this area and that there is more potential to further improve their use in building safety

Table 4: Application for AR, VR in AEC Aspect[4]

2.5.2.1 Enhancing in creation and optimization in VR mode

VR is corresponding to a 3D model of real-time representation as opposed to pre-rendered 3D model practice often discover in design corporation practices. Real-time 3D representation ensures the viewer is having a level of degree of freedom to communicate in the 3D world, typically in movement form.

The images which are rapidly modified calculated in frame per second. The amusing experience will involve immersive 3D simulation between 30-60 fps. This standard extends to VR nowadays, most of the virtual reality devices is having a 90 fps as maximal and each monitor shows each eye generating an image set in 45 fps.

[4] In conformity with Li, 2018 p. 21.

Increasing in demand for resources for rendering in VR, every developer must have his method of optimization by own. Some of these methods are already being executed for the application of rendering in real-time, particularly in videogames improvement, others are using a VR technology room for previewing (Li, 2018).

Benefits	Challenges
The projected overhead system	Big size to handle a model
(1080p@60 Hz) high resolution	Changing problems- texture and geometry
Immersive experiment	Mark-up, revision issue
More workflow in model development	Difficulties in navigation
Client and stakeholder's participation	entering location and time waste in travelling

Table. 5: Challenges and benefits of Roomlike VR system[5]

The optimization process helps users or modellers to make a successful 3D model without affecting much of the results. The 3D model developers, the people employed in the game industry, must have a strong sense of aesthetics as well as an appreciation of how the technology used to create the simulation in real-time works. This principle is important in helping the designers use the computer limitation effectively.

Determination of real-time 3D rendering of the graphical load is driven by Polycount defines a real-time 3D rendering of the graphical load. It is the polygon number that describes an object in 3D and is also correlated with the description of the sum on the surface. Developers tended to keep the numbers as small as possible to preserve the efficiency of the real-time rendering. The low detail was covered by the application of data on the textures of the product.

Optimizing the Polycount is about reducing an object's polygon number. Since polygon quantities decide how the form will look. Consequently , it is important to maintain the shape and general appearance of the geometric shapes when reducing the polycount if optimizing the polycount (I. Mutis, 2019).

2.5.2.2 The basis of VR in industrial design and object manipulation

After having ready packaging design products which have been created by users, establish a 3D CAD model with functions able to assemble the model virtually and presenting a result of virtual assembled. When it comes to operating object many issues become, like if you want to furnish a room you need to add all objects of the table,

[5] In conformity with Laura Maftei, Dragana Nikolic, Jennifer Whyte, 2018 p. 318.

chair, cabinet, etc. in VR accountability and need to allocate it accurately, in figure below shows how to operate the object to be understood the operation in VR mode.

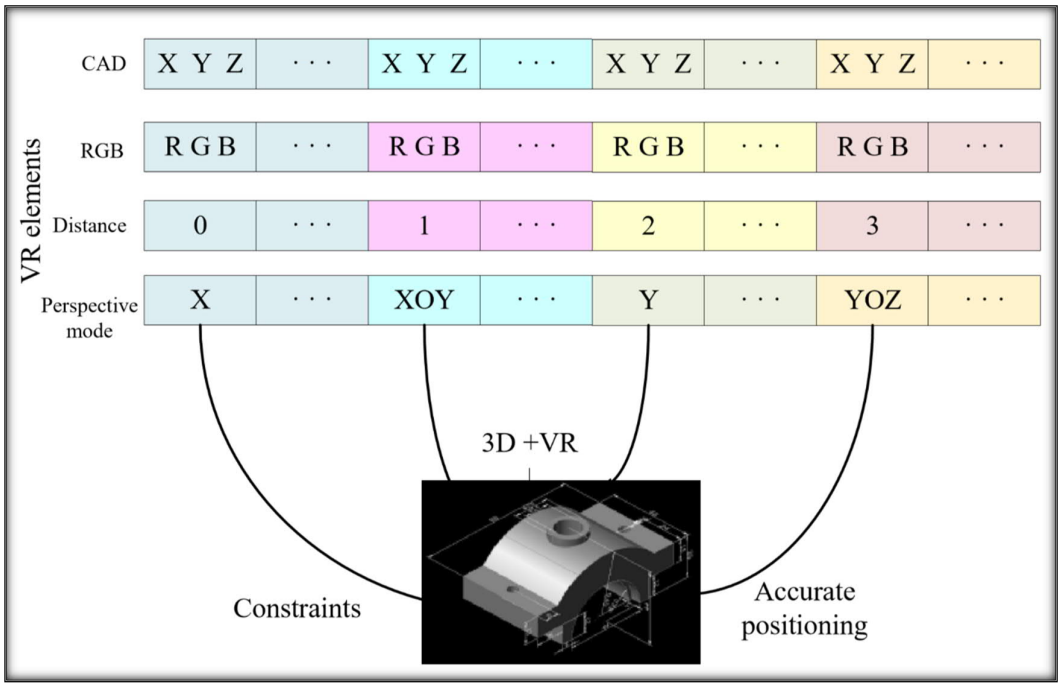

Fig. 12: Object setup virtually. Source: (Qi Yun, ChunLin Leng2, 2020).

2.5.3 VA and the technology of VR

The Virtual Assembly method allows motion sensors of a 3D model, by moving the parts away allows user to see in detail any collisions and even capturing a path to reload for further studies.

It is needed in CAD software when using VR application in manufacturing which is taking visuality as the master part to make engineers have a decision on relating of assembly through visualization, data techniques, and analysis.

VA is not commonly used at the present since problems are still apparent and still in the processing of solving.

Every AEC industry is pursuing developing the technology section to enhance the strengths between the project execution and planning. Engineer, architect, and contractor responsibility is to integrate and organize the activities and technical perspectives that each participant concerns on their work field, that they use in their work field.

Nonetheless, customers and consultants who are specifically not involved in the technical preparation and implementation, they frequently have a minimal or incomplete understanding of the process and the intended outcome. BIM has numerous agreement to promote and speed up preparing the construction project functions for experts (Rahimiana, 2017).

2.6 Mixed Reality

It can be identified as the digital and physical mixing view to unleash the obstacles between computer and human, and the interaction of environment indeed. It can be determined as the range of real reality and virtual reality, including amplified reality, Augmented reality, Mediated Reality, Augmented virtuality.

In 1994, mixed reality paper was published to discover the portion of the continuum of virtuality and applied taxonomy displaying. Since that time, it goes along displays to cover the positioning and locations in both visual and real spaces, the environmental datum, and spatial voice.

Mixed reality is a combination of VR and AR in immersive mode that by using HDM in AR mode turn it to be in a way of MR the literature does not provide a single definition of MR, but it may refer to:

- A more complex or dynamic mix of realities where the real world's boundaries are not evident to the user.
- Various degree of reality-Virtuality along the Milgram Reality-Virtuality continuum (X-axis).
- The wider understanding of all forms of truth. It should be noted that there is a tendency in favour of AR to abandon the word MR (Zorica A. Dodevska, 2018).

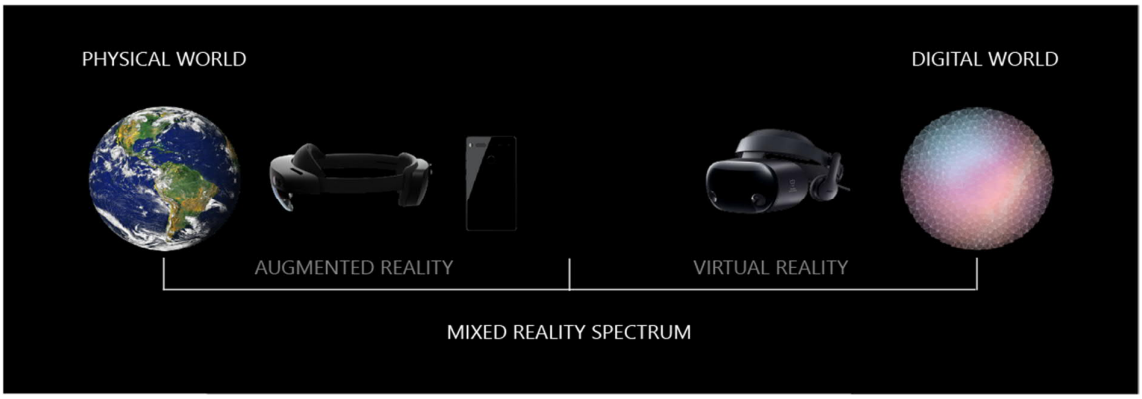

Fig. 13: Ranging from reality concept. Source: (Microsoft, 2020).

Architecture, Planning and Construction are continually trying to achieve new horizons with the benefits of emerging technologies: mixed reality has enriched their processes toward these modern destinies.

In today's world, digital manufacturing is a technology for everyday life pattern. This technology has been adopted by several businesses for the following reasons: to promoting data processing while the production stage of the product; to reducing the manufacturing production cycles. Moreover, to increase the degree of accuracy showing how often fails to happen in preparation of the factory layout. Digital manufacturing technique enables incorporated computational models generated by modelling a manufacturing system's logical and physical components, to accurately simulate their behaviours it uses the computer for this reason.

3. Technique and Methodology

3.1 Definition of BIM

Building Information Modeling (BIM) is a smart digital depiction of an installation's functional and physical feature. It acts as a shared knowledge platform for data about facilities that provides decisions with basic reliable from the outset during the lifecycle (buildinginformationmanagement, 2013).

BIM assists collaboration in lifecycle across multi-disciplinary participants, it models a 3D object that becomes a base-developed of parametric modelling produced by school research and creative software companies to match what professional engineers' requirements and architects' standards need (Autodesk, 2020).

BIM has had achieved good approval in the educational system that specialized in the architecture, engineering, and construction sectors, and managers (Karen Kensek, Douglas Noble, 2014).

The BIM design process in the life cycle of construction using visualization are probably a field where the synergy is most evident. In general, it involves in Value Design, design basis sets, Choosing by Advantageous components, client freedom of choosing the suited value, Cooperative Design, Quick Assessment of Design substitution, Streamlined purchasing and supply Network, Joint Review / Clash Identification, Immediate stakeholder engagement, Simulation / best target costing, Decreased Cycle Times and Waste in Design Activities.

3.1.1 BIM and data

AEC companies will largely depend on an extensive array of metadata to both create new value sources and reduce information threat as projects become complicated but even more. There are two types of data related to BIM, object data and metadata. Object data includes material, geometry, manufactural details, etc.

Whereas, metadata is organized information, according to the (ANSI) which defines, locates, explains, or otherwise makes it much easier to obtain, use, or handle an information database. It is usually referred to as "information on information". A broad range of options routinely collects low-level metadata, like the serial number of a data entity

or the designer's data. Metadata is carrying on an even more significant role in the cloud market.

It mentioned that different systems represent different criteria and a distinctive type of markets. IFC are, for instance, a frequently used type for BIM. It is structured to provide a reliable semantic description of the principles of design, their assets, and inter-connections. The IFC has a set number of data storage, data exchange and procedure regulations, IFC gives an optimal structure for handling building-related information during its lifecycle (Jing Du, Zhengbo Zou, Yangming Shi, Dong Zhao, 2018).

3.2 BIM and Virtual Reality

BIM-visualization is one of the important distinctions of BIM, the most i Designers can enter BIM datum in an intensive visual environment and manipulate factor analysis like type of material and cost that makes a development design effectively as in real-time mode.

BIM makes planning even better with VR technology to result in benefits like:

1. 4D Modelling

It is a way to combine the non-graphical and graphical project datum that relevant to the resource, time, management logistically, also, it allows any participant to easily enter and model a shared patterned mode. It enthuses project crew to cooperate in building 4-dimensional workshop virtually, as shown in the figure below, the modeller uses in VR platform the tools to drag and select objects.

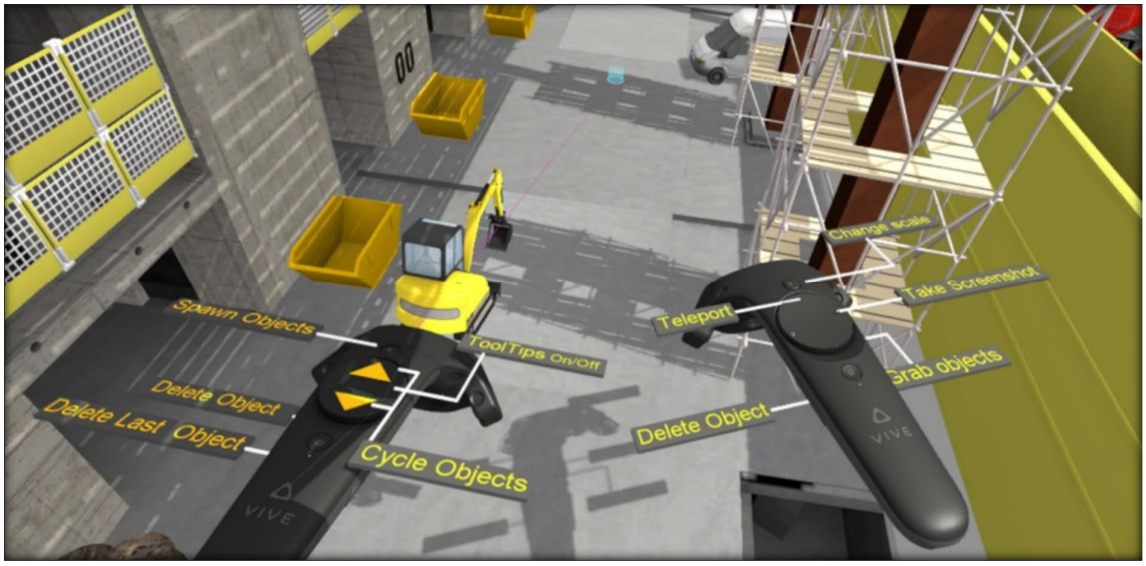

Fig. 14: Modelling in VR mode. Source: (FreeForm, 2015).

2. Clash detection

BIM-Enabled VR is one of the VR technologies used in CEET programme. It allows to design the building into 3D environment virtually with having all BIM pertinent necessary datum with no adhering to peer into 2D sketch, it fosters to detect the clashed and tracing process clearly.

This is one of the linkage terms with BIM-VR in terms of the training field, it is model-dependent that emphasizes data linking to tackle and simulate the construction process. Softwares like Revit or most of Autodesk tools give the trainee the ability to move this conventional 2D sketch method to BIM-VR reactive environment, and building maintenance and management datum in virtual mode to let planner understand how all factors integrate to each other.

3. Decision-making tools

Many tools developed to help in making the decision and process improvement also decreasing rework like developing to visualise on-site construction work by integrating 3D modelling with schedule data. It assists to have a clear view for deciding whether it needs modification to have well-proceeding in education or construction, also questioning trainee is included in VR technology to improve their experience in learning or teaching (FreeForm, 2015).

3.3 BIM and AR integration

One major advantage of our architecture is the integration of as-built BIM software and the use of real construction data. To integrate BIM and AR engines effectively we define three issues that need to be appointed. The virtual objects used in AR can derive either directly or indirectly from those in BIM. The three issues are as follow:

- Locate the identical virtual objects in BIM, i.e. authoring, given the image at the location.
- Store the details in an overlay.
- Publishing and writing functions are another major benefit of the proposed system, which addresses the problem of collaboration in AR.

Announce problem in this study, refers to multiple users displaying Augmented Reality overlay at the same moment. Composition, on the other hand, relates to a multiple AR view simultaneously scenes created for one designated user by different users.

These functions are based on BIM and AR integration and extended further with our BSNS. Both need the help of the organizational framework of BSNS, and the mechanism for access control.

3.3.1 BIM-U and BIM-phase channel

"BIM-U" is an application software which enables end-users to track the effectiveness of on-site activities. All data used to upgrade the 4D model of the project improved with various cost variables like earned, real expected, and cost value.

"BIM-U" android app, and a "BIM-Phase" channel which can also be accessed IOS and Android systems, both supplement each other by reviewing the work progress, visualizing the real progress and contrasting it to the expected modelling.

3.3.1.1 Methodology

The proposed framework advanced by creating a mobile application called "BIM-U" and the channel "BIM-Phase" which can also be seen on ISO and Android. 'BIM-U' and 'BIM-Phase' supplement each other by reviewing work progress, visualizing real-world procedure, and contrast it with the expected model. The suggested applications built using an integration of resources and components, as follows:

1- Primavera: This framework is entitled to build time schedules using the resource-assigned CPM method.
2- Autodesk Revit: BIM models built using this framework.
3- Fusion tables: This is a web-based data control service offered by Google that enables data collection, visualization and sharing selection, like Google-connected Microsoft Excel drive. That used herein familiar, spreadsheet-like rows and columns for updating the actual length, cost, start, end, and output of the activities.
4- MIT App Creator: App Inventor is an open-source cloud-based platform that uses the Java programming language to create Android apps over a web browser. This tool is broken into a community of functional blocks and a planning interface that enables end-user activity.
5- Metaio Creator: Metaio Creator is a tool that lets AR scenarios be generated and deployed.
6- Junaio: The AR channels generated using this smartphone app. Created by "Junaio" channels supporting location-based services, QR code, ID tracker and bar code detection and 2D image tracking.

BIM-U is an Android application that is better to other business applications, because the data collection can be used in any other scheduling application, such as:

The MS and Primavera. BIM-U created using the MIT Software Creator, a brief overview of which had been given above. MIT Software Developer proposes three different approaches to designing and debugging to set up the live checking of the built application prior launch. The related apps can be operated without downloading any software if the device plugged into the internet connection is on during the using of an Android device (Mohamed Zaher, David Greenwood, Mohamed Marzouk, 2017).

The figure next page shows the numerous applications to make up the proposed AR system that incorporates the functionalities of the various applications that can be accessed on the Junaio AR browser. The structure of the built Android "BIM-U" technology includes that all data processed into one application. The implementation process happens in the MIT Software Inventor tool. MIT Software Inventor Companion is recommended for viewing the built application on a computer. If the computer is not accessible, then software must be installed on the machine to allow Android simulator to

be used on-screen.

Finally, if no internet link accessible, appropriate software must be set up on the machine so that the link to the Android device created through a USB connection.

Figure (15) depicts an example of using the blocks feature to create a login screen. As the data obtained from the application used to update the model, the 4D/5D model displays the distinction between the project's actual and planned advancement.

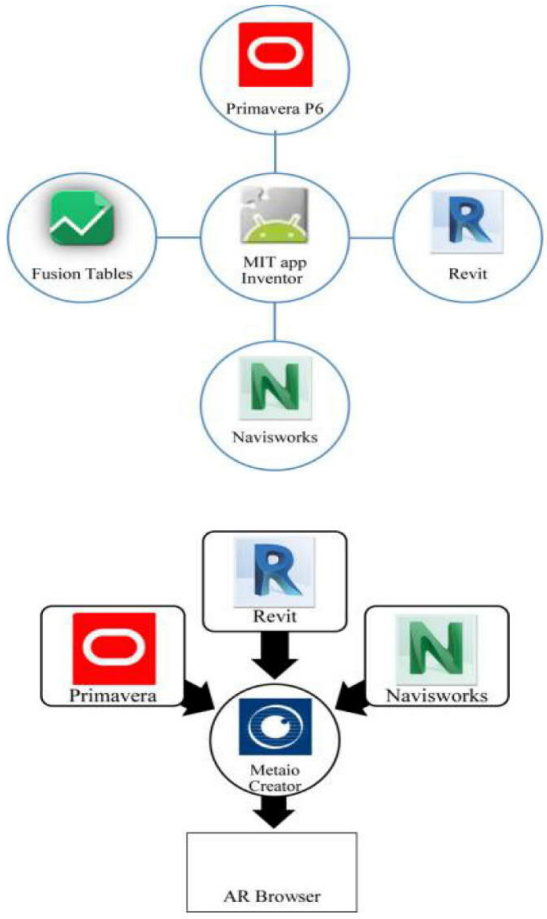

Fig. 15: All related programmes in one application integration. Source: (Mohamed Zaher, David Greenwood, Mohamed Marzouk, 2017).

3.4 Construction and BIM

BIM methods have greatly enhanced design and construction management in projects in recent years. The knowledge models incorporate the initial stages of project creation.

On the other hand, the industry has developed systems and software that generates

models in 3D, 4D (time) and 5D (budget/cost) that enable simulation and coordination in the later design phase of what will be executed and monitored, enabling better collaboration between working teams and better understanding.

However, in the construction phase, providing the design details in 2D papers, with manual procedures, using drawings, excel sheets, etc., or bringing a tablet and displaying the 3D model in a 2D screen is still a common occurrence.

It is thus a manual job to create a relationship between the construction project and the technical dossier. Finally, construction management and inspections are often carried out in 2D, making tracking progress very fatigued and vulnerable to mistakes, which can have ramifications on the quality of the building and the importance perceived by users (Brioso, 2018).

3.4.1 4D virtual construction and BIM

Visualization allows us to realize the project in detail at the first stage. It starts with modelling in 3D BIM platform then integrating the duration to have in result a 4D BIM modelling, then the enterprises produce the project detail accurately when impose the AR mode to allow the client walking through the model, suggesting for any changing desires before even start the excavation process.

AR can make task scheduling in HMD cooperation, it called MR since the user can use the headset to preview the visual object with other required instruction related to work. In many companies like (Innovaya) Visual Simulation combines BIM objects with scheduling operations, carrying out 4D design preparation and study of the buildability. It helps enhance logistical preparation for project communication, teamwork, and development.

Including its powerful 3D engine and incredibly user-friendly interface, Visual 4D Simulation allows you to create a streamlined set time resulting in project time reduction and playing what-if-scenarios with conventional GANTT chart schedules. Many examples use in construction management, part of it uses in scheduling and collaboration.

Greatly improve the scheduling component of the construction project; it will show an as-built vs as-planned model to allow progress to be visualised. Figure (16) demonstrates the four methods of presentation scheduling methods, one method is a 4D

model the preparation and progress monitoring through the Navisworks software for the construction project. The model's white colour section is complete, and green is not finished currently, and it will be done within the next step. The green part also reflects the projected activity comes up, and the AR mode is displaying the timeline of the project along the simulation running set (Sebastjan Meža, Žiga Turk, Matevž Dolenc, 2015).

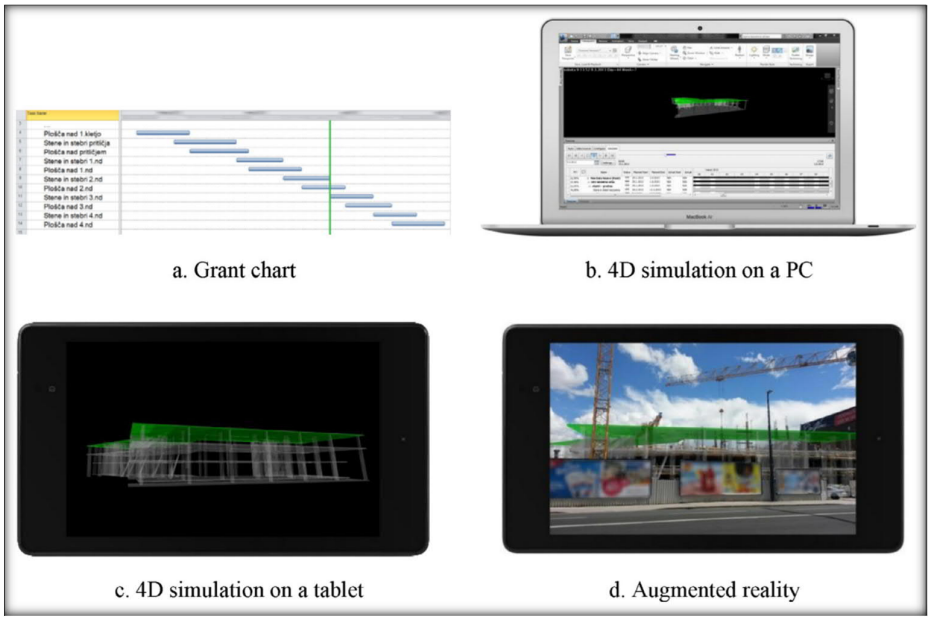

Fig. 16: Presentation Method Comparison. Source: (Sebastjan Meža, Žiga Turk, Matevž Dolenc, 2015).

Koo and Fischer (2000) proposed that adding a 'fourth dimension' (time) to a 3D-model would be beneficial for project planning in management and construction. including 4D CAD,4D Planning and Scheduling, 4D-Modeling, 4D Simulation, 4D Technology and 4D site management model or 4DSMM.

However, existing CAD resources would not have the frameworks to annotate models in 3D and 4D. CAD information, such as interruption checkers, must be transferred to a third-party tool that offers more graphical features. It is evident from this terminological variety that 4D planning includes connecting a time schedule to a 3D model to enhance the techniques of construction planning by:

- Visualisation of the relationships between construction activities space and time.
- Analyze the building plan to determine its execution.

- Reducing errors through the interrogation/validation plan and enhancing co-ordination between project team members at the same time.

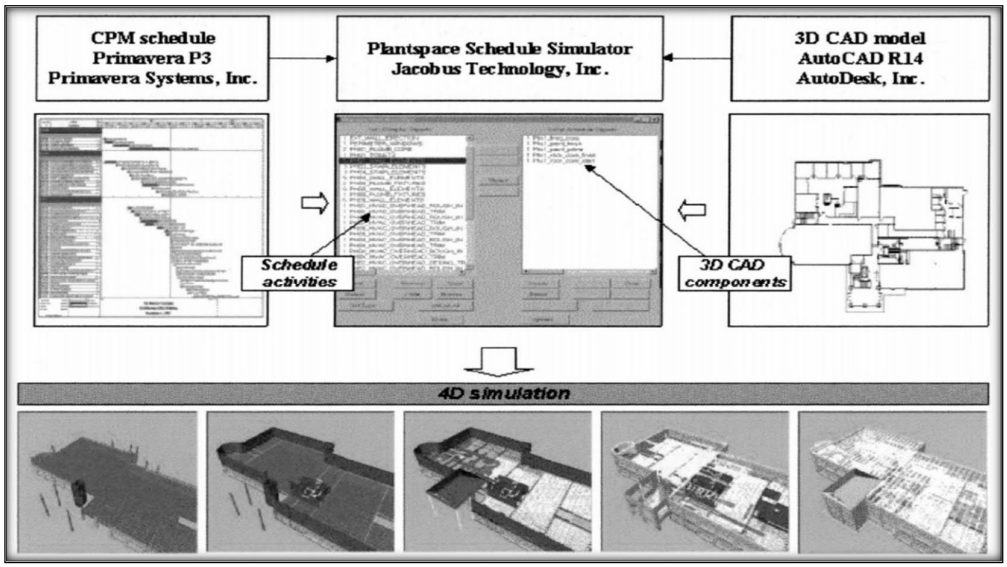

Fig. 17: Development of 4-dimensional CAD model. Source: (Bonsang Koo,Martin Fischer, 2000).

The idea of locality with the schedule is not lately established, in fact, the roots of 4D can be traced back to the late 1980s in a partnership between Bechtel and Hitachi Ltd and the work of Fischer and Stanford University associates who developed the original technique for visual 4D model development. Technology has evolved over time to include the freedom to model and reinforce the project quality.

In 2017, the second publication of the CIBO's book describes the latest 4D modelling which provides projects handled by Freeform company specialized in advanced 4d modelling. The company established in 2007 with a team concerns on the 4D concept adding tools for communication.

One of the projects is BISHOPSGATE, a complex commercial high rise building in London city with law elevation level of complex basement and the challenging in organizing with the project team to demolish the current erected structure, although, the following schedule amendments of 4200 activities was one of multi-complex (I-Hong Hou, Narges Zarnaghi Naghsh, Sibendu Paul, Y. Charlie Hu, Atilla Eryilmaz, 2020).

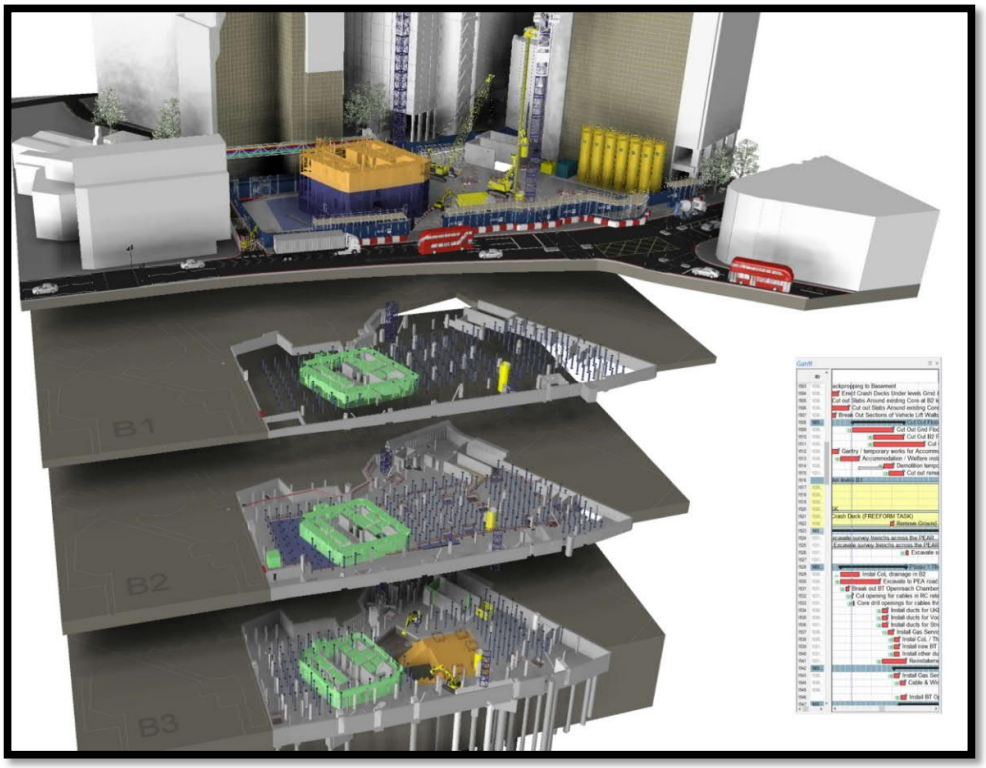

Fig. 18: 4D virtual commercial high-rise building in London city. Source: (FreeForm, 2015).

Although earlier versions simply used 3D 'dumb' modelling in design software and allowed time associations to be incorporated, dedicated virtual construction (VC) tools now require multiple models to be incorporated, and schedule data to connect intelligent objects to individual resource-loaded and logic-linked activities. Using 4D will boost the efficiency of the planning process in a variety of ways.

Integrating both to work alongside the so-called 4D tools (3D model + scheduling) is typically planned by the Gantt software- and this is defined in detail in the management chapter, both can be built within a GIS using the database management method to maintain the construction complement data to support the planning field.

These include the ability to collect information from a structured repository of project information; enhanced ability to classify activities through model interrogation; and period estimation using automated processes for quantity extraction.

Such changes would allow the planner to create more precise schedules and communicate aspects of the plan more effectively including construction methods and sequence, guiding the plan recipient to the exact location of the job material, and impacts

of resource movement and site logistics), It may also illustrate dangerous practices. (Bonsang Koo,Martin Fischer, 2000)

A major challenge for the future Virtual Reality (VR) applications is to offer high-quality experience over Wi-Fi communication with restricted bandwidth, within both terms of content quality and responsivity. Some research proposed to tackle this problem by exploiting the predictability in the virtual environment of user gestures. Researchers consider a wireless connection, where multiple VR users served by an access point (AP). They demonstrate that the VR application form comprises of two unique practices, in which the controller has different perceptions forecasts which will occur at the second (deadline scheduling) step over the first (proactive scheduling) stage (I-Hong Hou, Narges Zarnaghi Naghsh, Sibendu Paul, Y. Charlie Hu, Atilla Eryilmaz, 2020).

3.5 Unity 3D engine

Unity is a game-making engine used recently to cover all fields, in the construction field, its obsessed enterprises to include it into their work field. Visitors have a hard time knowing and feeling these intangible historical identities of the surrounding region.

For this reason, there is always the need to go forward and improve new methodologies for learning the cultural heritage and appreciating art, and digital technologies are increasingly supporting this. Instead of having a difference in HMD crafts in a direct way presenting from the traditional AR method, a new way of interaction created using low-cost technique, VR technology and 3D Unity technology.

Usage of the AR platform accomplished by using HMD, tablet, jump motion and applications generated in Unity 3D. In a virtual physical environment, it let users to active easily and fully with the intangible historical identities. It can be fulfilled through organized scanning control to target base surface, to experiment photographic measurement, and to design procedures on the basis of the human natural interaction principle. To provide virtual prototype files, a local intangible cultural heritage model database can then be created (Shaohui Li, 2019).

In general, the full scene does not need to be displayed. However, numerous sensor data need to be analysed for tracking system deployment, and 3D registration. As a result, a general requirement arises to run with specific platforms, and core technology support.

The outlet work of the AR system consists of:

1. Bringing information from a real-time scene.
2. follow up the information obtained by the sensor.
3. initializing virtual object generated.

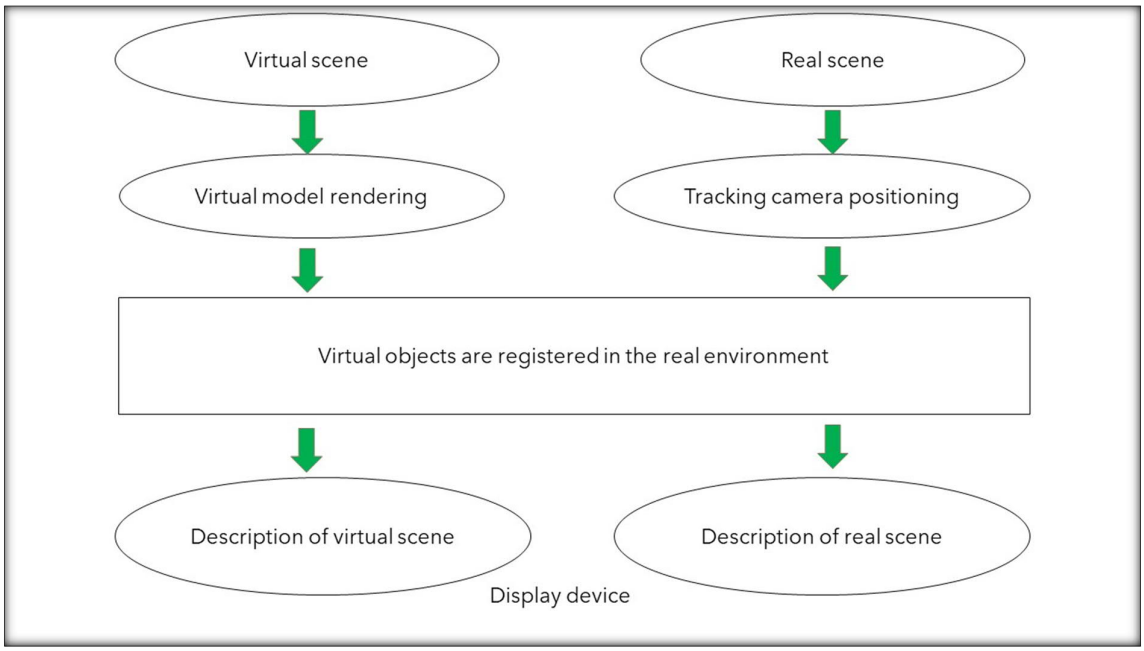

Fig. 19: Workflow of the AR system. Source: (Shaohui Li, 2019).

3.6 Integrated development environment

Unity and Visual Studio are consistent with each other, any other C Sharp programmes would not be easier to use than VS. Encoding and scripting are important to identify the goal of AR/VR project, this what makes virtuality benefit to using.

IDE for Visual Studio is an innovative launchpad that can be used for editing, debugging, creating code, and publishing applications afterwards. (IDE) is a fully-featured platform that used in software development for several purposes. In addition to the debugger and standard editor offered by many other IDEs, Visual Studio provides compiler optimizations, compiler tools, graphic designers as well as many other features to simplify the work of software creation.

3.6.1 IDE features in Microsoft VS

The user can be more productive in VS project development by some features that are covered in:

- Quick actions and squiggles are frizzy outlines that warn you like your text to errors or possible problems in your text. These visual clues help you to quickly fix problems with no need to wait for the error to be discovered during build or while running the software. If you are swinging over a squiggle you can see additional error detail. A light bulb with actions, known as Fast Actions, can also found on the margin to correct the mistake.
- Print your code with the click of the mouse and add any suggestions for code fixing by your design style settings. The editor configuration conventions, and Roslyn analyzers. Code Cleanup allows you to fix problems with the code before going through the review process. (Currently only available as C # code).
- Refactoring is a way of updating code to simplify learning, managing, and extending with keeping the behaviour on the way, it involves operations like removing one or more lines of code into a new method, smart variables renaming, , modifying the order of parameters of the scenario, and many more.
- IntelliSense is a definition for a collection of features which shows information directly in the editor about your code and, in some ways, write down small lines of code for you. This would be like getting inline basic documentation in the editor, that keeps you from needing to search up information about the sort elsewhere. Features of IntelliSense vary according to language. See C # IntelliSense, Visual C++ IntelliSense, JavaScript IntelliSense, and the Microsoft visual IntelliSense for more detail.

Although Visual Studio comes with its C # compiler, if the user is search for errors in the C # scripts, Unity also uses its C # code to have a scripts remedy. It is also very convenient to use the Visual Studio compiler make a reason that users do not need to turn to Unity periodically to check whether you have any mistakes in the project or not.

The C # compiler for Visual Studio has a few more characteristics than the C # compiler advocates for Unity. That means that some code (especially newer C # features) in Visual Studio can not drop a mistake, however, in Unity does (Unity, 2020).

The figure below shows the four fundamental components of BIM-VR integrated BIM, cloud database, game engine, and HMD in VR.

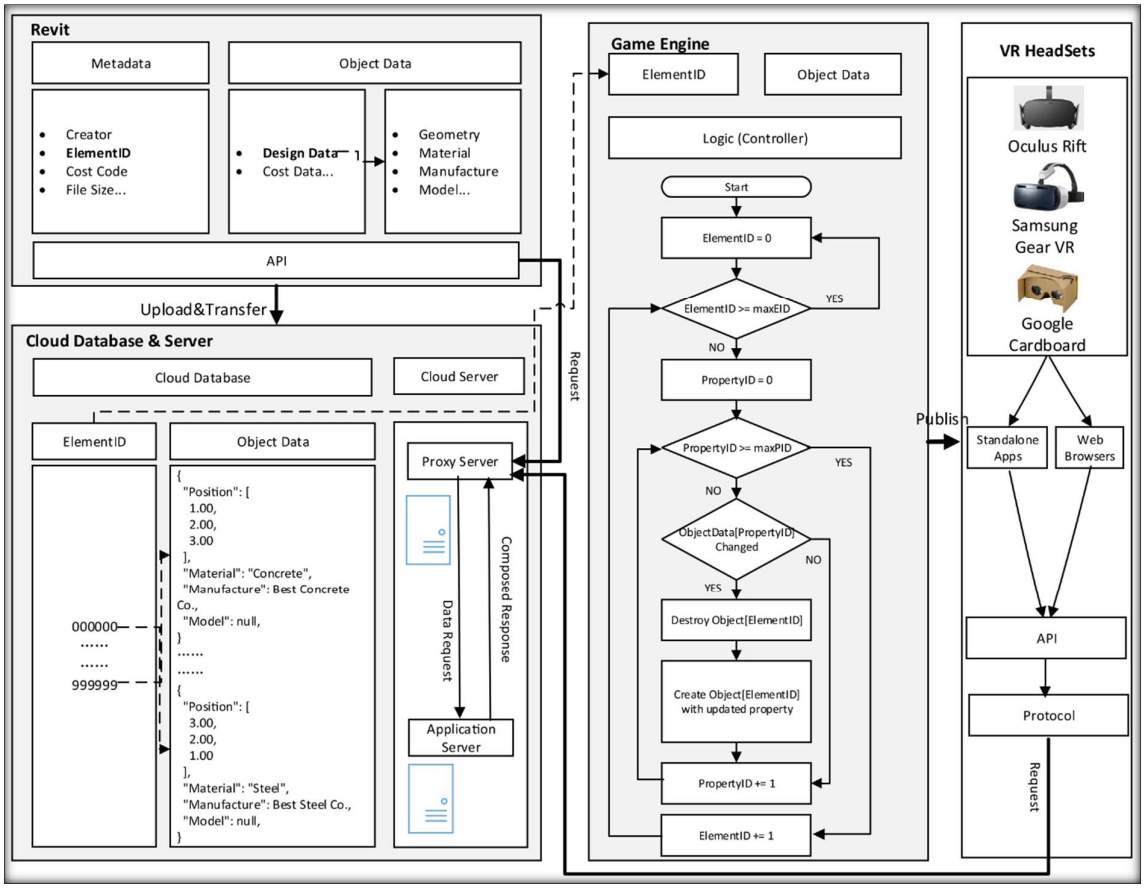

Fig. 20: BIM-VR components. Source: (Jing Du, Zhengbo Zou, Yangming Shi, Dong Zhao, 2018).

3.7 Prospect program and VR delivery:

Prospect one of IrisVR company that concerns on the BIM-enable virtuality to visualize a 3D design, the programme scans a 3D file and dispatches in one touch to an interactive, navigable surrounding VR. IrisVR has improved a program to have a framework upon virtuality with codifying the necessary elements for required procedures in order to eventually output a VR model, there is no preparation and no scripting. It simplifies the VR process delivery, both centrally for analysis of the office design and externally

with company customers. It has helped users lift the bar in their market for business location and strengthen their role as technology leaders (IRISVR, 2020).

Most of websites like Prospect software is applicable to render and present all necessary layouts individually in immersive and non-immersive scenario. In the case study one, there has been used the Prospect just for presenting to the client and gain the required level of satisfactory besides, to segregate components and layers, but this program it gives the user the ability to quantify and storify as each object defined and recognized in Prospect, usually it responds for IFC formats, which is combined all AEC models in one format to ease the process, make the model able to use seamlessly.

4. AR/VR in Management Domain

There are lots of participation in various fields and related PM by using AR/VR application. Instead of traditional 2D drawing and rendering style, investors and consumers can now witness realistic images of their future homes, apartments, business locations in riskless and affordable cost. The implementation of AR / VR technologies in a project substantially intervene in all types of management (time, cost, risk, product, planning, etc.).

In this part, it introduces the using of VR and AR in safety, cost and time management, a clear case study integrates types of managements to a project showing how technology would substantially influence positively to the project workflow (Zorica A. Dodevska, 2018).

VR can intervene in walkthrough animations, wind tunnel simulations, fire and life safety simulation, clashes detection, structural analysis, emerging and lighting, 4D,5D cost and scheduling simulation. AR can make a clear monitoring and diagnosing data gathered from controlling and management system, also VR technology allows a project manager to identify a vast number of visual artefacts.

It is precisely by walking around a simulated construction site using Real-Time Walk-Through apps that a contractor can get the site situations up to date. This technology is suitable for observing in a three-dimensional space allocated components and construction machines.

Real-Time Walk-Through technology can be used in construction planning since a planner can visually check the construction site's conditions, such as the scaffolding structure and construction equipment as if he/she were on the actual site. Throughout the building, a manager can observe the location situations in a site office via the virtual world, without any effort to walk around.

The work can be more collaborative in VR design effort that involves more participants to meet in a web framework, discuss and inspect the project point out all problems and difficulties, the problems can be tackled in a virtual mode plan platform (Naruo Kano, Okubo,Shinjuku, 2006).

4.1 Cost and time management

Undoubtedly, cost and time are the main parameters of the building process. All construction project management's purpose is to cut down on completion time and save building expenses, the construction time and expense control occur from the beginning of the construction stage. Although, it is not substantially successful at any point in the construction process. To maximize the productivity of construction management, it needs to shorten the construction period and use different ways in technical development.

VR can by using some software like CAVE to reallocate resources to make a smooth graph of the resources and income labour. Approximately 14–19 per cent of the money and 9–13 per cent of the time lost because of sketch planning misrepresented, or inaccurate transferring information from the design to the actual target (Ahmed, Shakil, 2019).

4.1.1 VR management

Improving the practical management of any construction undergoes by implementing VR application on a 4D model (3D model plus time). However, VR does not solely have a perfect interface, but the virtual environment interacts as a real-time tackling and discovers solutions of problems as it finds in the real world.

4.1.2 AR management

AR-based apps in the construction department for tracking and managing time and cost issues have emerged significantly for the continuation of the project. The project managers need AR technologies to identify the projected amount of materials and labour cost reduction that can figure out in AR mode and prevent errors and construction rework. Nevertheless, researchers face some practical difficulties in the preparation of hypothetical VR content, such as 3D scenery, graphics, pedagogical manners and the matter to adhere workers to a stationary facility (Li, 2018).

4.2 Planning management

Planning is a crucial management part since it orientates employees to focus on work processes for successful required output and test the employee's ability. It relays on the performance of organization management that either to fulfilling project aims or failure to achieve (Mohamed Zaher, David Greenwood, Mohamed Marzouk, 2017).

Product Name	Developer	BIM Use	Developer weblink
Navisworks	Autodesk	Detecting clashes	www.autodesk.com
		Scheduling works	
		Coordinating works	
Projectwise Navigator	Bentley	Detecting clashes	www.bently.com
		Scheduling activities	
		Coordinating works	
Dp Manager	Digital project	Scheduling activities	www.digitalproject3d.com
		Reviewing model	
		Quantity take-off	
		Collaborating works	
Visual 4d Simulation Innovaya	Innovaya	Coordinating works	www.innovaya.com
		Scheduling works	
VICO Office	Vico software	Scheduling works	www.vicosoftware.com
		Quantity take-off	
		Estimating cost	
Solibri Model	Solibri	Detecting clashes	www.solibri.com

		Scheduling activities	
		Collaborating works	
		Design review	
		Quantity take-off	

Table 6: Examples of BIM tools for planning management[6]

4.2.1 AR in planning management

The usage of AR mode is beneficial in the field of construction management, it possible to operate 3D models on 2D sketch paper.

The project management plan is affected by several factors. In some case, we can simply put a basic implementation plan but the benefits of using VR technology likely not be valuable and preferably to transpose VR interface to a complicated project plan.

Planning is helping to minimize the business riskiness by deciding on the project effectively, besides the employee motivation and capability to undertake the work diligently. It is going through many factors like measurement checking, clash detecting, and object modelling.

Fig. 21: Virtual building on a tangible base plate (target mesh). Source: Author.

- Measurement Check:

It helps in the construction field to model, drive, and schedule the project efficiently and accurately by using advanced hand tools, sensors, and cameras. Also, improving safety, managing cost, and simplifying collaboration, it can measure the height, depth,

[6] In conformity with Mohamed Zaher, David Greenwood, Mohamed Marzouk, 2017 p.4.

and width of physical properties, briefly, space is recognized while using the AR platform (Stannard, 2019).

An automated measuring can take place on-site during construction development, workers can use the AR headset or devise to measure between objects. Furthermore, workers are exploiting to reveal any clashes in the structure during the measurement.

- Building Modification:

AR-enable device's capability in integrating all documentation of the project and digital knowledge is a big challenge, it allows users to modify objects on-site and relocate any component instantly.

4.2.2 VR in planning management

In the technology part, the Prospect is running BIM's QA and QC in VR to boost analysis and RFI performance. With three steps, it can bring the complex BIM model into VR:

1) Sending the 3D view to the program.
2) Process and launch the experience.
3) VR mode environment displaying.

The planning crew put the VR headset and all required instruments to have the ability to walk through on-site virtually.

4.3 Benefit study of VR in the building management

Historically, computers had a weak resolution, slow refresh rate, and low in the field of view (FOV). HMD's have regained prominence in recent years. If users use VR, the display refresh rates and updates can control to motion sickness if it has used for a long time. Nevertheless, in recent years the technical breakthrough has eased the solution of problems, that makes its adoption feasible and affordable for safety training with relatively wealthy construction firms.

The 3D format is essential for the development of 3D construction models in the construction industry. True three-dimensional models, time-consuming and costly, inspire

engineers to follow VRs. It is advantageous for the construction sector if engineers can reduce the VR presentation difficulty (Li, 2018).

At this part, we are going to talk about benefits in DPR company, DPR construction is a professional contracting business with a passion for performance. In 1997, a commercial and national enterprise built up and ranked in the top 50 in the country of a general contractor. The company is famous in reasons that make customers prefer and recommend to DPR company, like good cooperation in managements, trust, experience, although facing extraordinary project with difficulties and able to succeed.

In their section, VR is a large-scale project execution technology that meets the criteria defined in documents in the project, detailing the results and observations of the VR program applied on many construction projects in DPR. As a result, DPR is working on a plan that addresses various technical criteria for successfully implementing VR at this particular level of the project (DPR, 2020).

- Cases of VR throughout project lifecycle:

In DPR, projects are going through five stages: plan, design, coordination, construction, and FM, the table is providing the scene of VR usage at each stage.

Plan	Design	Coordination	Construction	FM
The charette of design	Reviewing the design	Visual makeup	Reviewing complex infrastructure with contractors	Displaying the coordination between Eh&S, Fm, and Bim model

Table 7: The life cycle in VR cases[7]

VR solutions can extend over the whole life cycle of the project to bring value and greater predictability to the project.

At the earliest stage of a project While planning and designing time, VR can be extremely useful in helping planning crew carry out an end-user analysis and gain input from the room users. After that, the crew will integrate the suggestions and import data

[7] In conformity with Kaushal Diwan, Raymond Huynh, Ocean Van, 2017. p 3.

from end-user ideas into the design drawings.

Useful insights can be provided into the moods of different rooms, office and lobby furniture configurations, hospital medical equipment layout, personnel workflow, visual sightline review for accessing security facilities, nurses work, and security guards, etc.

VR collects user's metadata, monitoring where they concentrate their attention across heat maps in virtual space and foot traffic. It helps to expose trends in which users communicate with the building, which can help to influence the use of space and give evidence for architectural features creation and validation (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

4.3.1 DPR challenges throughout the different field

DPR tackles challenges during some cases as follow:

- During community outreach

VR addresses the project and faces obstacles when implementing the project. This allows main project stakeholders to imagine, understand, and visualize efficiently the logistics of the project and good connectivity with the developer's team, stakeholders, and any other involvers. Often, VR can be used to generate anticipation with the viewer and end-users, to introduce the product.

- During the process of construction/ coordination

Instead of physical mockups, VR can be used to build virtual mockups which allow differentiating finishing advantage and more complexity in installations, often misinterpreted when viewed only on screen. This immersive VR experience helps to match priorities between owners, designers, and contractors regarding the installation of complex or high-end finish work.

It wealthy proven by some examples like:

- Identical rooms for patients with complex processes impacting patient and hospital managers.
- Operating rooms with a complex configuration of the medical devices.
- Large physicists / doctors / nurses job spaces.
- Kitchen/server space to support lots of people in a day.

- A large lobby space, where an understanding of traffic space and direction is crucial.
- Working spaces in study facilities around lab banks; etc.
- In case of any fixation and maintenance, FM uses the most significant instruments to detect the target, orientate to access maintenance (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

- During the coordination process in MEP works

Meanwhile, FM may need VR to study the access panel layout to obtain a practical understanding of where and how open they are. It is also necessary for facility managers to determine the locality of equipment considering as the most effective tools to resort when it is needed as well as orienting for servicing procedures. You can straight relate this input to alternate in the BIM to be modified as per required.

- During the planning of safety

VR can help the Environmental Health team at DPR to check up all major safety points which is crucial to ignore, like coordinate the way to shift and lift the facilities and how much care it would be after construction and during utilization.

In this case, the interactive VR experience allows for an efficient way of visualizing and communicating the effects of significant construction activities in existing facilities that may potentially be overlooked when viewed using conventional methods.

- During site operations

Preparation to convey the effect and disruption of construction activities to residents in nearby areas, people in adjacent buildings and those in the same construction.

- During operation and facilities management

In final handing over of the VR model to facility managers, they can access by having metadata which includes names of tools, instruments, all that relates to conservation works and detailed report. It also helps facility managers to lead, educate employees, and take/give advice as well as supply useful knowledge about the location of equipment. Creating security measures for places that are not readily available (e.g., storage

spaces, clean rooms, etc.) (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

VR model gives the client a good view and better understanding of how the system operates and this is after handing over The hand-over of a VR model will give building owners and facility managers a greater understanding of how construction systems operate.

This also allows them to provide instruction for construction managers and employees; to provide better maintenance through a clear understanding of access criteria, equipment location, etc.; to establish safety measures for areas that cannot be easily accessed. In figure (22) shows the obstacle vision was released in VR by moving the façade a bit to accommodate all the sight (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

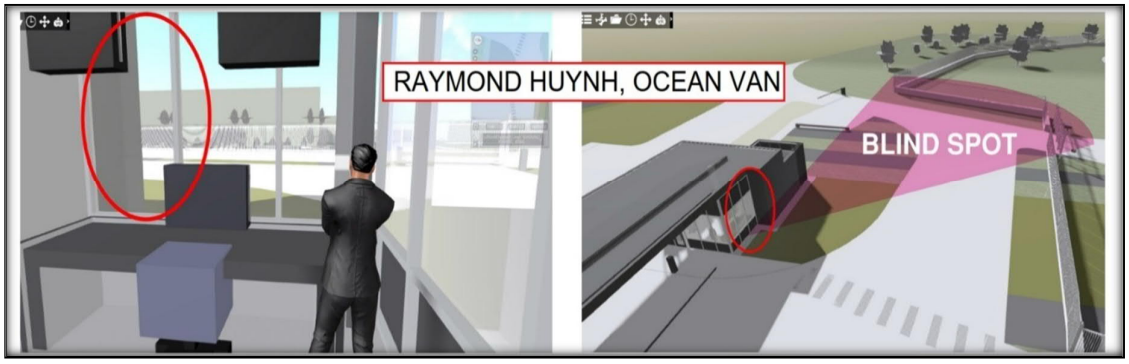

Fig. 22: Blind spot resolved in VR. Adapted from (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

The most VR benefit comes while taking some factors into consideration be the most effective figures to value proposition of VR implementation on any project, these are:

- The Right Mindset of VR

By using communication tools and relying on environments, where an involved team can contribute, and create successful VR participation to make a valuable project. As such, VR's success depends on the capacity of a project team to create an atmosphere in which people can communicate freely and contribute to the project's success.

The (Big Space) contains two delivery methods to reinforce a project environment as well as helping in VR implementation; Design-Build, and Integrated Project, these methods suit projects characterized by:

- Good confidence level with team managers

- Feeling a part of the responsibility
- Neutral and opponent mentality
- Open-mindedness across new processes and technologies

- Complicated Projects:

Behind the complexity of projects which require multi-functional cooperation between various project stakeholders will reap the best benefit from being able to envision the final product accurately through VR applications. Types of VR projects provide the most updated value in case of having faced complicated projects (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

4.3.2 VR in setting realistic anticipations

In DPR projects, they are not expecting to consider showing a realistic walk through the building virtually with a superb headset as one of VR benefits but solving problems in the result of VR model is the greatest trend of success in the project, besides gaining user's satisfaction.

User Challenges-VR will engage end-users and allow them to provide input on a variety of solved questions in terms of areas like:

- Is there enough workspace?
- Am I feeling relaxed when involving in this space?
- Is there any distortion in vision?
- Is accessibility protected and compliant with safety standards?
- Can prefabricated components be mounted more effectively on the equipment to fit better with the nature of the surrounding elements?

Next figure shows an example of objects interruption in walkthrough realistic virtual environment.

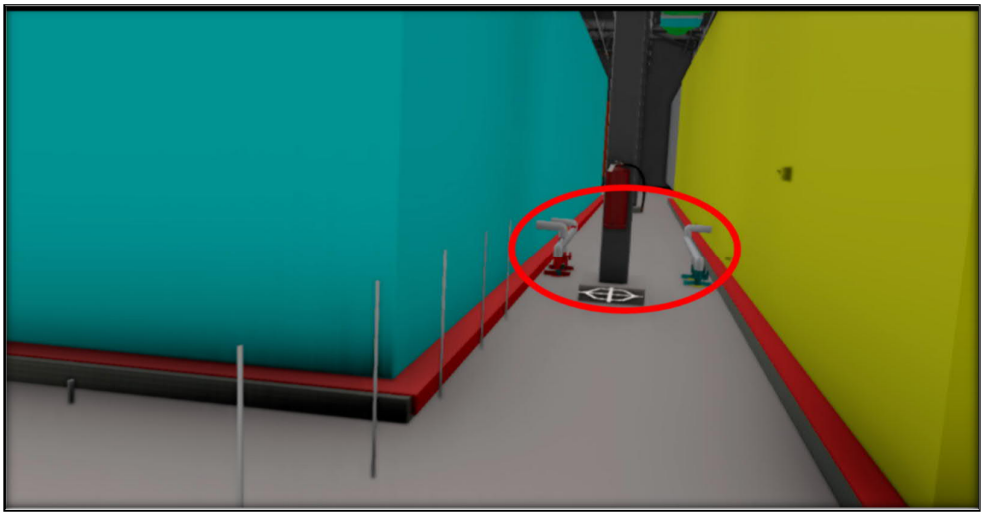

Fig. 23: Contradiction between objects close to the structural column by using VR. Adapted from (Kaushal Diwan, Raymond Huynh, Ocean Van, 2017).

4.4 Safety managment program

4.4.1 AR in safety management

In the building industry, the system of safety department is a very troubling problem in nowadays. Hundreds of people die in building accidents worldwide every year. Another most important thing for any construction project is the training of employees. Such problems are by no means easy to solve at the required basic level. AR systems, however, assist all problems in delivering appropriate instruction to workers and in implementing the safety management program as requires..

Fig. 24: Counting labours by AR-based wearable goggles for construction safety. Source: (International, 2017).

4.4.2 VR in safety management

The obvious truth about VR technology is that it offers the ability to plunge into a new dimension with a new depth of real-world digital creation that reassembles in real life. In an industrial construction project, construction projects cope with the reality of employees and consultants. likely to fail in some points, because of issues. These issues linked to incapacity, inaccessibility and inexperience of field personnel and consultants.

In construction industries safety is a curtail matter because of dangerous and unique nature of risk and uncertainty. Safety is urgently needed for every worker as a priority before beginning any project, thus, training should take as considerable concern in construction, the safety and quality are mostly depending on the adequate and intensive training of employees or labours (International, 2017).

4.4.3 Driving and safety training scenario

Safety training has always been considered one of the most effective resources influencing the safety knowledge and efficiency of staff, the actual work atmosphere sometimes deviates from safety training and education orientation. It would be hard to predict and recognize safety hazards and provide the right data in the right direction.

Virtual reality technology has been used in (CEET) platform; it relies on vitality over time. In some specialist's view, the visualization structure classified based on VR positioning, in terms of RV the relationship between reality and virtuality, four variable stages is to be determined; Augmented reality, Augmented reality, and the precedence of the clear virtual and real technique. When specifically talking about the virtual reality technology, it mentions to the prudence of the clear virtual technique is highly focused on the communication development in shared work pattern (Peng Wang,Peng Wu,,Jun Wang ,Hung-Lin Chi,Xiangyu Wang, 2018).

The CEET classifies VR technologies into five main types on basis of the visualization usage and used platform displayer, those include VR immersive, 3D VR games, BIM-VR, and AR.

BIM- VR ability is allowing users to design the building into a 3D environment virtually with having all BIM pertinent necessary datum with no adhering to peer into 2D sketch, it discussed in the previous chapter.

Research theme	Duration				Sum	Percentage
	1997-2001	2002-2006	2007-2011	2012-2017		
Desktop-based VR	6	3	3	5	17	26%
(VR) immersive	1	1	1	1	4	6%
3D VR game	0	0	0	4	4	6%
BIM- VR	0	0	4	27	31	47%
AR	0	0	3	7	10	15%
Total	7	4	11	44	66	100%

Table 8: Publication of BIM-VR distribution based on the technology year[8]

- Desktop-based VR:

As shown on the table above, this VR technology is the dominated and commonly used back in the earliest phase, it is simply monitored by the computer as a previewer for acquiescing virtual activities.

This technology does not have a tracking system it needs users aware of what is surrounding them. it only requires the standard tools like keyboard and mouse and is considered to be the oldest in comparison to the other VR technologies.

V-REALISM is one of the most remarkable improvements in this technology. It specialized in improving trainee for maintenance procedures by using CAD to model the construction part then preview it on other software like what called OpenGL programme.

V-REALISM embraces a systematic framework for the structural model to ease the operation and ordination virtually. It is one of the main achievements as similar to ICML, It improved to remedy the disruption in education and on-site project by using the construction tools and methods (Peng Wang,Peng Wu,,Jun Wang ,Hung-Lin Chi,Xiangyu Wang, 2018).

- VR in Immersive Technology

The immersion created a panoramic image with real sound affection to provide a real perceive in a virtual environment. One of the immersive programmes is the CAVE. It

[8] In confirmity with Peng Wang,Peng Wu,,Jun Wang ,Hung-Lin Chi,Xiangyu Wang, 2018 p.153.

developed by (Waly,Thabet, 2003) to positioning the user locality and what surrounding him, so, whenever the user positioning has changed it synchronize to follow his position virtually.

- VR 3D Game Technology

Videogames are the most joyful interactive way for training enhancement, it aims to integrate collaborative interface through students to proceed task requirements as it should be in real-life pattern, moreover, it uses in construction but merely it focuses on 3D videogames to simplify the clash boundary and trajectory method in order to minimize the complicated process, this technology is identified by the clash limitation and the geometric attribution, it helps to detect the collision and minimize the complexity in processing (Li, 2018).

- Augmented Reality

Most previously published VR studies based solely on the vehicle-driving simulation method. A lot of users have recently embraced learning technologies for simulation. Drivers will develop their driving abilities and be more conscious of their driving issues.

This strategy makes frequent driving issues less likely following graph shows the Idea of virtual realty car simulations:

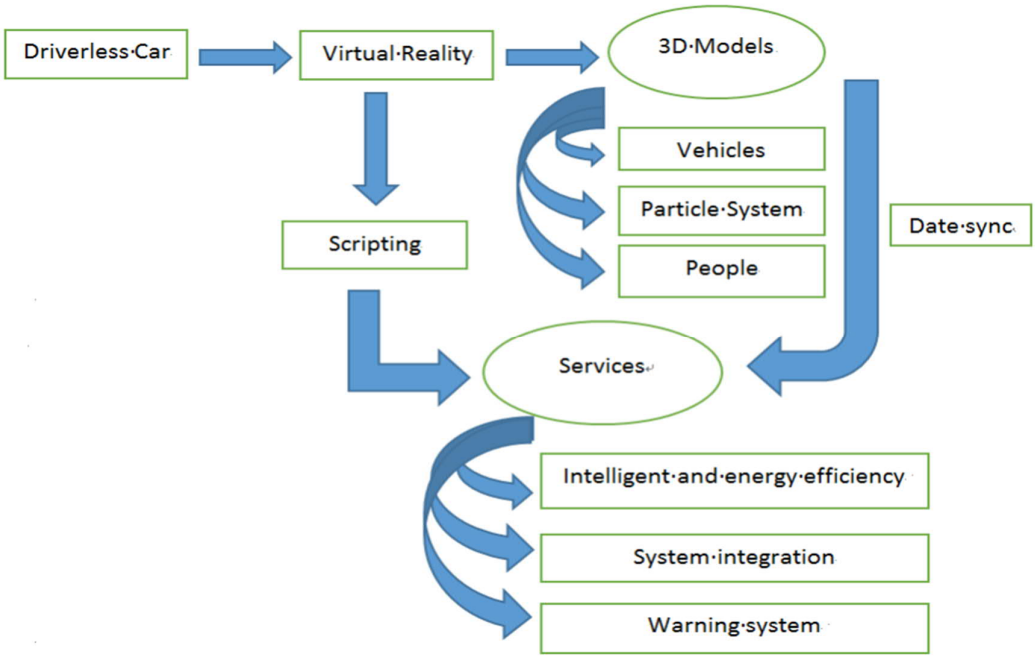

Fig. 25: Standard VR STS. Adapted from (Li, 2018).

The basis of nature of construction place and failure of experience, purpose-designed training utilities are often simulating the construction site. Workers must enrol in VR training course or by traditional non-virtual training which might cause deadly accidents. Applying the action and observing the immediate results will stick it in trainee's memory for the long term and enabling students to interact along together with virtual 3D surroundings.

4.4.3.1 Virtual training system against hazards

One effective scenario of hazardous prevention is to create a virtual on-site environment, especially when constructing towers and high-rise building. Safety needs to take into considerable concern and test worker’s safety and ensure the instruction education has been successfully fulfilled. One of the examples to blend virtual and physical objects to have in result a hazardous scenario is creating a virtual wooden shelf as a way to link between two in-site building with real view, standard and dimension. Labour clothes also can synchronize the motion in the same way the user moves his hands.

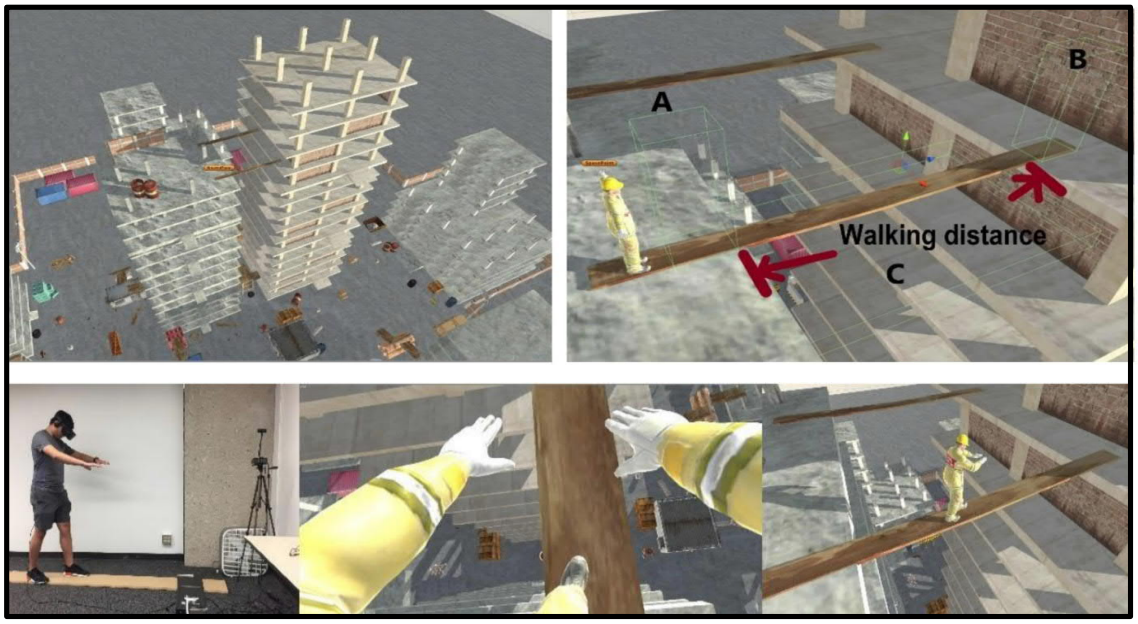

Fig. 26: Virtual Motion and Real-Environment Setup. Source: (Yangming Shi, Jing Du, 2016).

The builder must have to walk carefully from zone A to B with corresponding distance as in real, on walking through the wood, the tester can feel the same awareness required in real and virtual view is coming from realistic BIM model (Yangming Shi, Jing Du, 2016).

In result, it way beneficial from the traditional education and participation fulfilment in terms of trainee response and interactive, generalize features and not specify, many specialists preferred to train of it can be as following:

- The trainees easily respond and interact to give the ability in an increment of freedom degree
- AR involved in improving practical teaching
- Previewing 3D model including objects is more influence than 2D sketch drawing
- The daily activism improvement was becoming a key feature in AEC training programme as the technology exponentially changes day after day.

As we mentioned previously, the risks identified while proactive works following the on-site activities, that helps to ensure a protective safety project and secure all meeting with only stakeholders and managers by using pre-designed virtual construction project sites in the digital library.

Health hazards, hazardous situations, instances of incidents and task lists can be educed from a database of health details. The details can then be used to render templates for virtual websites. The database will be revised once site supervisors and officers complete any of the instruction and inspection activities. The safety manager can be supported by (RII) to learn more about safety training for employees and the scheduled field inspection. New risks treatment resolve during security inspection can be automatically placed in the database.

The Freedom company which worked on the 4D project modelling, it did work on safety manner as making a trainee sit virtually on-site in a view inside the crane cabin. He can control and make movement all the angle and get to use the future position in real site working (Yangming Shi, Jing Du, 2016).

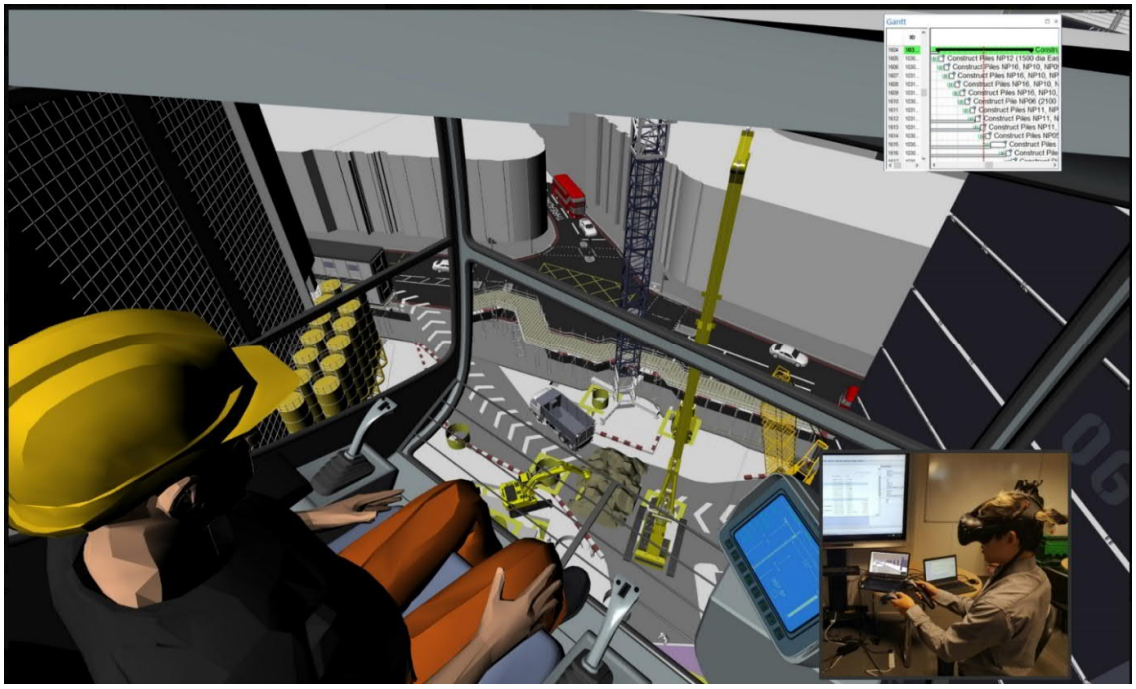

Fig. 27: Training Simulation. Source: (FreeForm, 2015).

During Coronavirus, all school's lockdown and the studying is becoming virtually. Therefore, using VR is the safest way to prevent student infection while experiencing what in a real site. The Ricoh Theta S360˚ technology allows to scan 360˚ panoramic view and digitize images then send it to VR headset to let students study in safe and well protected from any infection (Jeffrey Kim, Tom Leathem, 2018).

4.5 Defect and quality planning

In South Korea, RC job is roughly composed of 23% of total building costs, which is a very high portion of income construction costs. Furthermore, the construction time takes about 57 per cent of the whole period of the building. That would cause a lag in the RC work in circumstance of process jamming for later work. Besides, deficiencies in the RC function happen frequently, leading to an increasing in the costs it Planned.

- Augmented reality perspective:

Many finished projects approved by the client that are either defected or failure to achieve the target standard especially when disagreements occur. AR plays a major role in global construction in introducing automation into the defect and quality

management system. Different research demonstrates the important usability of AR in QA / QC. (Ahmed, Shakil, 2019).

AR compiles real environment of virtual graphic images and elements from the real world and provides them into a camera to show users with a new modern computing environment. In building project, this assists users to provide with environment suits the reality and for computing visualization uniquely. New stakeholders at the worksite, including project manager, labourers, and site supervisors from participant construction companies, may use smartphones such as desktop Computer to control deficiencies using AR (Jeffrey Kim, Tom Leathem, 2018).

AR smartphones allow people to view real types of projects with BIM models. Through this, workers can efficiently and effectively check the outcome of the work at the early stage of construction worksite, thus, prevent inattention that causes mistakes.

The scenario for using the DM-AR app will be defined as follows in figure (28):

1) The defect manager uses the BIM model to verify the details needed for RC project defect management, such as the design of the structure, the components, and the project timeline. The defect manager then transforms and stores the details that can be detected in mobile devices.
2) The defect manager passes the details from the BIM structure to an ARToolTik., the data after that documented on the AR markers. All the marker classified as per its place of work.
3) construction site managers can notify subcontractors throughout meetings with managers and staff, and their respective indicators place for attachment. (Kwon et al,2014) illustrated the method of marker-based AR technology for defects and quality control, as shown in Figure (28).

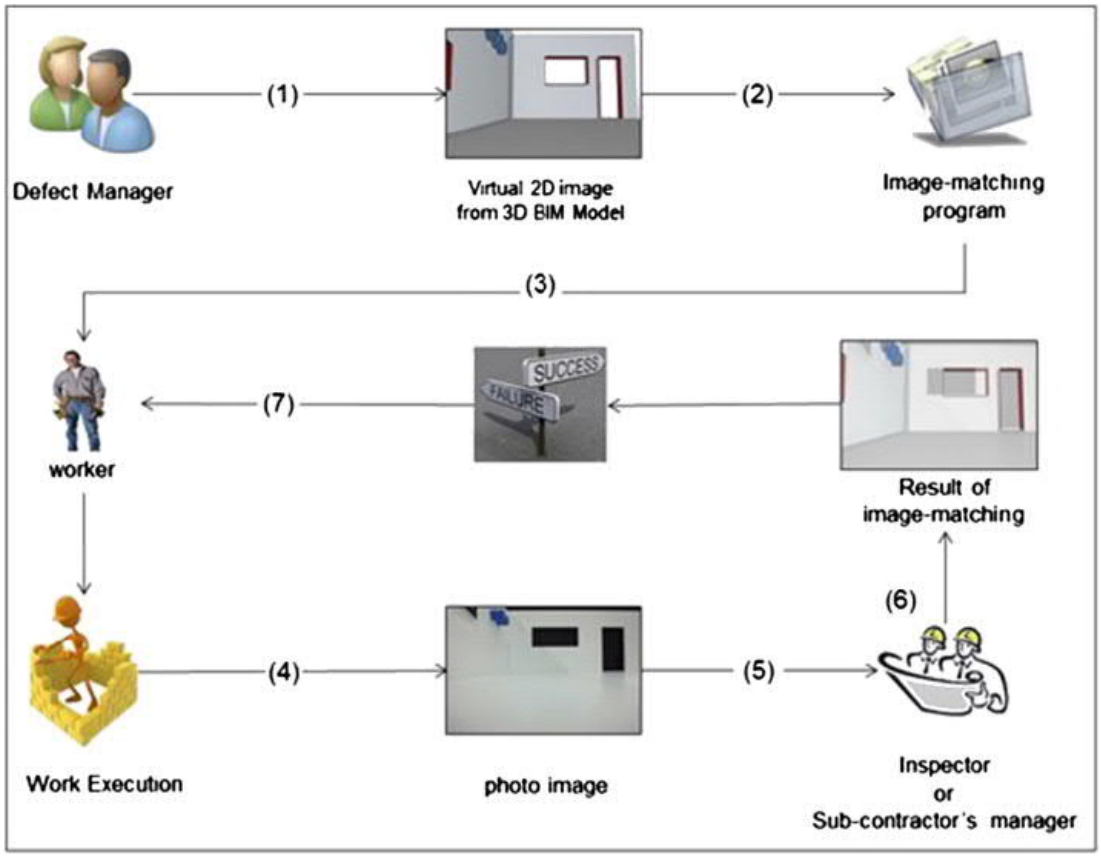

Fig. 28: The stages of defect management by using augmented reality. Adapted from (Kwon, 2014).

4) The staff then fasten the markers to certain designated positions and then use the smartphone DM-AR software to expand the BIM geometry knowledge decision-based. They can either view the AR-BIM Geometry material that is overlaid on elements of the real site since this enables inspectors and site managers to track the condition of RC's job and finds any inaccuracies quickly.
5) Once the working area has done, DM can request staff send a picture of finished work. DM-AR APP will submit those photos to the site managers directly those who inspect.
6) Inspectors and site managers may use these photos to evaluate work performance and search for defects which might cause defects.
7) Whether any consistencies detected, employees are requested to avoid related tasks promptly, and revision request to sent in the DM-AR app via the work order warning feature. The process of DM-AR carried out after the workers have finished rework.

An important method for recognizing and correcting defects has developed to encompass AR technologies in the QA / QC sector may promote both the entire construction cycle and the key tenure era (Kwon, 2014).

- Virtual reality perspective:

The defect management program was an expensive and time-consuming problem before the VR developments in construction. The defect is often ignored, and the report gets skipped or harmed. Nevertheless, the defect control becomes very simple and efficient with the aid of VR technologies. There is no need for physical labour to maintain this process. This method of handling the defect and efficiency is thus saving energy, costs, and time.

5. Case Studies

In this part, it introduces the ways to apply the literature parts of this report. The two case studies are introducing and each one is talking about the construction project applying in AR and VR modes, the first one is applied by the author.

5.1 Case study: Virtual, Augmented Reality in (WeDo project)

WeDo is an idea of company incepted in 2016, which concerns on construction and advertisement parts. This project is one of the ideas that use Visual Studio 2019 C# script to encode command lines based on which important parameters used to define the crucial results which often project managers need it on site. Still, this project is illusional made by the author and its simple residential and industrial building.

The project located in Al Farafra Desert, Egypt but the cost calculation in Euro currency with outpoint some features by using virtual/augmented reality and showing how management shall be schemed, in addition to raising the client's satisfaction.

This case study inspired by Sri Ram Srinivas; a modelling developer who summarize within 10 min a virtual and augmented reality in a small presentation. By using a tablet device as a sensor, he visualized the model Vuforia engine program after setting up the AR camera and as it is going through focusing on the residential project through this study to hand the concept of BIM usage with a simple building. In this study, we ignored the industrial building as a model interface since both buildings have the same meaning in respect to VR, AR idea, see figure (29).

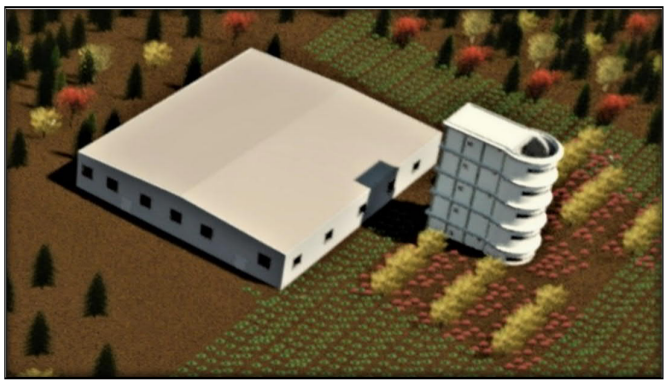

Fig. 29: Realistic model of the whole project. Adapted by Author.

The project has not arisen yet so some assumption should be considered in this case study, the project duration assumed to start in the first of April 2020 until mid of October 2020 regardless the pandemic infection we are going through nowadays.

The project is modelled in the Revit structure 2019 program and exported to Navisworks 2019 to schedule all activity with planning and actual duration. The challenging is to import the cost and time in a virtual platform and list some observations noted by users while running the VR/AR platform, thus, improving in the management aspects, in this case study we visualize and feature out what upon the residential building only, see figure (30).

Fig. 30: Revit extracted in PNG format. Source: Author.

After the agreement has approved with the client and the final draft has already done and revised with compliance to the requirements. The time and cost scheduled in Excel sheet attached the predicted and actual budget, in the below page the types, activities, and durations are shown on the table (9,10, and 11).

Column schedule				
Family and type	Volume m³	Cost	Total cost	Area m²
Column and foundation, concrete	0.3082	100	30.82	4
Column and foundation, concrete	0.3067	100	30.67	4
Column and foundation, concrete	0.3067	100	30.67	4
Column and foundation, concrete	0.3067	100	30.67	4
Column and foundation, concrete	0.2846	100	28.46	5

Column and foundation:concrete	0.2846	100	28.46	5
Column, concrete	0.2507	100	25.07	6
Column, concrete	0.2507	100	25.07	6
Column, concrete	0.2368	100	23.68	5
Column, concrete	0.2368	100	23.68	5
Column, concrete	0.2359	100	23.59	5
Column, concrete	0.2111	100	21.11	5
Column, concrete	0.2111	100	21.11	3
Column, concrete	0.2111	100	21.11	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.1975	100	19.75	3
Column, concrete	0.155	100	15.5	3
Column, concrete	0.155	100	15.5	3
Column, concrete	0.155	100	15.5	3
Column, concrete	0.155	100	15.5	3
Column, concrete	0.155	100	15.5	3
Column, concrete	0.155	100	15.5	5
Column, concrete	0.155	100	15.5	5
Column, concrete	0.1453	100	14.53	5
Column, concrete	0.1453	100	14.53	5
Column, concrete	0.1453	100	14.53	4
Column, concrete	0.1453	100	14.53	4
Column, concrete	0.1453	100	14.53	4
Column, concrete	0.0974	100	9.74	4
Column, concrete	0.0974	100	9.74	4
Column, concrete	0.0974	100	9.74	3
Column, concrete	0.0825	100	8.25	3
Column, concrete	0.0783	100	7.83	3
Column, concrete	0.0783	100	7.83	3
Column, concrete	0.0783	100	7.83	3

Table 9: Column and foundation cost. Source: Author.

Floor schedule					
Floor level	Family and type	Area	Cost	Volume	Total cost of slab
Fifth	Floor: concrete	91	100	35.75	3575
Fourth	Floor: concrete	91	100	35.75	3575
Third	Floor: concrete	91	100	35.75	3575
Second	Floor: concrete	91	100	35.75	3575
First	Floor: concrete	91	100	35.75	3575
Ground	Floor: concrete	124	100	48.44	4844
Total					22719

Table 10: Floor cost. Source: Author.

In Revit, the concrete price is100 € per cubic meter, the overall RC slab cost 22720.75 € whereas the RC column of 300 mm cross-section cost 736.82 €. which is shown on the table next page. In result, the cost details that include the labour cost extracted from the Revit quantity and the concrete ready-mix price as shown below on the tables.

During earthwork, the land surveyor takes place to fetch as-built points for computing cut/fill datum and estimating the amount of required soil with using AutoCAD CIVIL 3D programme, that stage comes earlier in the construction phase.

Active	Name	Planned Start	Planned End	planned cost (€)	Actual cost (€)	Saving cost (€)
1	Project duration	2020-04-01	2020-04-16			
1	Earthwork	2020-04-01	2020-04-20	15,000	15000	0
1	Soil excavation	2020-04-13	2020-04-21	35,000	34000	1,000
1	Backfill	2020-04-22	2020-04-22	10,000	9800	200
1	Mounting the tower crane	2020-04-23	2020-04-30	4,000	4000	0
1	Foundation for both building	2020-05-01	2020-09-06	15,000	14,500	500
1	Ground floor (column)	2020-09-06	2020-10-12	10,000	9,000	1,000
1	1st floor(column, slab)	2020-06-10	2020-07-09	10,000	9,000	1,000
1	2nd floor(column, slab)	2020-07-10	2020-08-10	10,000	9,000	1,000
1	3rd floor(column, slab)	2020-08-11	2020-09-09	10,000	9,500	500
1	4th floor(column, slab)	2020-09-10	2020-09-29	10,000	9,500	500
1	Mounting the roof	2020-09-28	2020-10-06	8,000	7,500	500
1	Dismantling the tower crane	2020-10-07	2020-10-13	2,000	2,000	0
1	Plumbing works	2020-07-10	2020-07-24	12,000	10,500	1,500
1	Electrical work	2020-07-27	2020-08-07	16,000	14,500	1,500
1	Installation of equipment	2020-08-10	2020-08-21	7,000	5,000	2,000
1	Closeout phase					
1	Preparation of the ground	2020-07-10	2020-07-23	1,500	1,000	500
1	Utilities underground	2020-07-24	2020-08-06	14,000	13400	600
1	Landscaping the territory	2020-08-07	2020-09-20	8,000	7700	300
1	Project hand over	2020-10-16	2020-10-16	197,500	184,900	12,600

Table 11: Project duration and cost. Source: Author.

The sequential matters are to preparing the model on Autodesk software's like Revit and applying all objects and cost expense. then preparing a simulation in Navisworks but here the C # script has customized to make options in controlling the simulation to have ability to monitor at each stage and list all important observations and warning notes.

- Methodology

In this case study, the Unity program is utilizing the use of technology such as 3D modelling and BIM that commonly used nowadays to proceed planning. Virtual technology is making a framework of project management by using Vuforia and C# scripting programmes within Command-Line surface (CS) format generated by Vuforia. A script is encoding according to the requirement needed to show on the device output.

In any project, usually (cost estimate, labours income, materials) are the elements which are taken into account when encoding by C# script, those elements presented in the end to project manager and stakeholder devices.

What next is describing the steps of encoding the elements necessary to the planning management:

1) The project is modelled and exported to the Navisworks to make schedule planning simulated.
2) Make a new Unity project, import the model, and identify the base of what the model will virtualize on it, make sure the BIM model is capable with videogame and Vuforia engine.
3) Creating the image target mesh to be the base paper of the model that Unity recognizes it.
4) Once the schedule prepared, the Visual studio is taking place to create a code environment in the right commands describing the desired project constraints (cost, time, and quality), and make whatever is required to gain the client satisfaction and all project participants.
5) Finally, creating a viewer from folding terrain after having the UI, and coding stuff ready, the more function you have, the more complicated you got, the most important is to put the right script file and prevent any errors while scripting commands line.

Some engineers offer ready online scripts for what the user desires and previewing which elements client prefer to provide on the platform as feature outlook that gains client satisfaction. It may need some modifications to suit for the specific project but probably needs project disclosure which likely the client denies and requires for confidentiality.

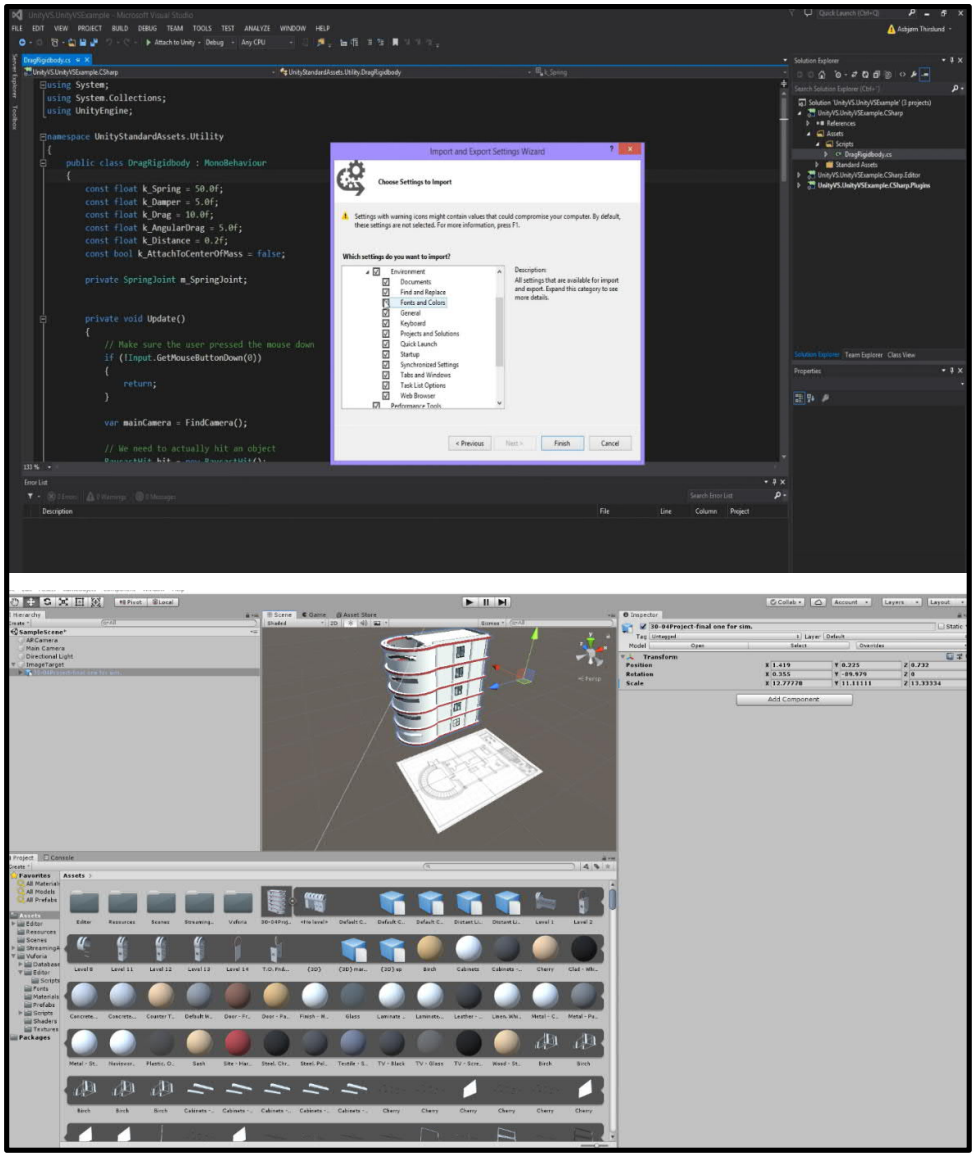

Fig. 31: The model and the image target mesh in unity and codebase initialization. Source: Author.

The project is ready to be visualized by Vuforia software with using the type of monitor which is, in this case, a mobile device Samsung 8 plus) connecting to the computer and some configuration of detecting the paper to set up sensors and detecting the objects, then build up the visualization model as shown in the figure below.

Vuforia uses to operate project appropriately and ensure that goes on accordingly, and the UK has already given a BIM Level 2 public project requirement from 2016.

Fig. 32: Beginning- ending scene of the virtual building. Source: Author.

Also, the model rendered in Prospect software to preview a VR mode, walk through the project, able to leave comments and allocate the project, segregate the layers to show how concerns for what. For example, structural designer, changing day-night mode, and many more satisfactory in options and no need to attach a headset to walk through it see all details, and capable to detect clash aspects. See footages in the figure (33) next page that has been rendered by Prospect software.

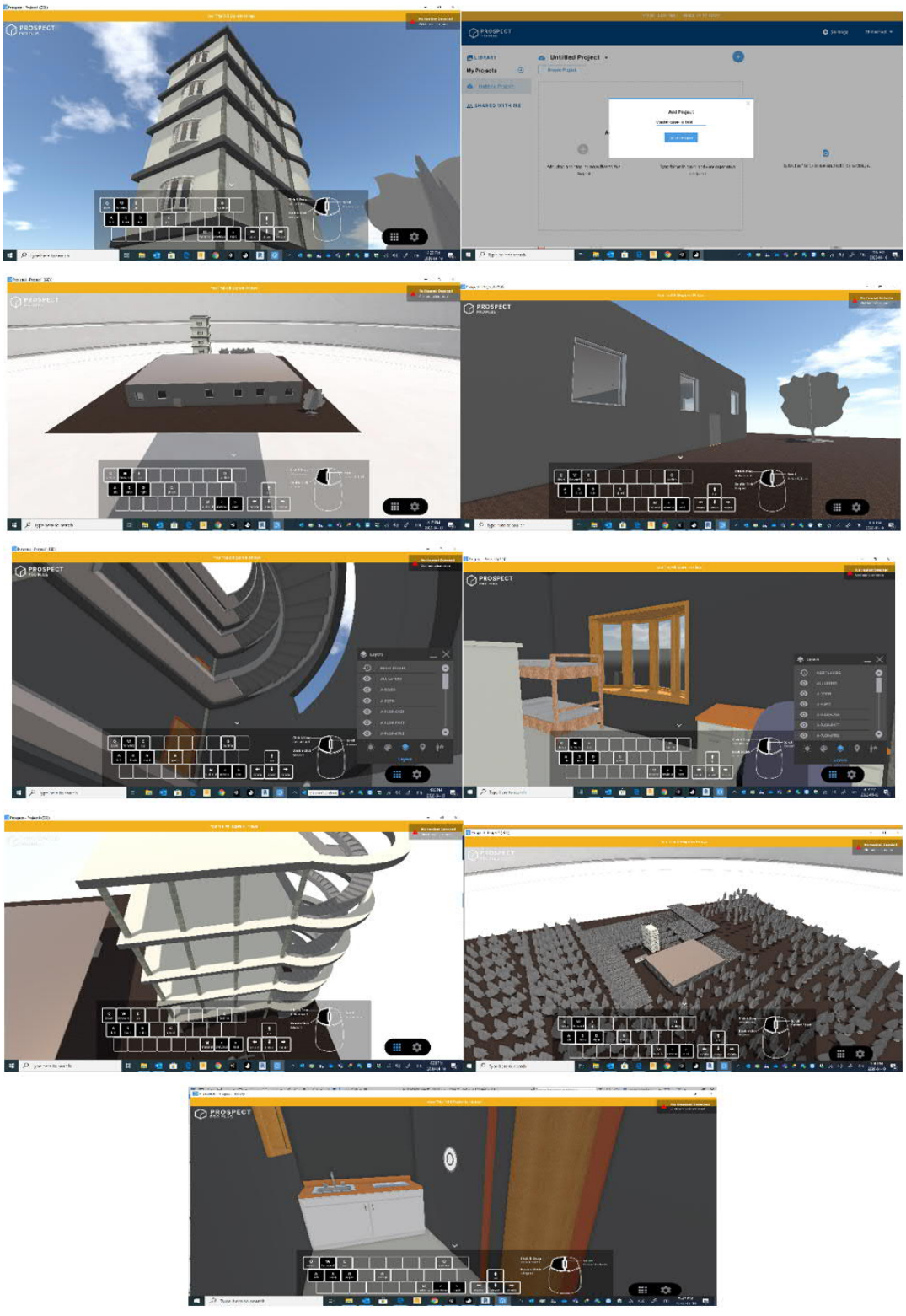

Fig. 33: Project VR perspective in Prospect programme. Source: Author.

5.2 Case study of a project of 3D BIM roller coaster in the ice mountain

The project is in Zhuhai, Province of Guangdong, Hengqin Island. The project is one of several Ocean Park entertainment facilities. A roller coaster attached in an altitude, reach 22 meters from the ground and having multilayers rotary and reach the maximum altitude 60 meters. It runs through the cave and around the ice mountain which has a complicated shape that makes it tricky to construct, other facilities included like excavation passages and water pool.

Our obligation about this project is to have a 3D model of an ice mountain, set out the mountain structure, and have support steel planning following the design drawings of entertainment. also, landscape company agreed to carry the concept of design and all amusement instruments and facilities into account and measure the mountain into scale by using a specialist to directly determine the measurement then import it to 3D CAD model.

Fig. 34: Iceberg model and entertainment utilities. Source: (Wang, 2013).

Usually, projects are modelling by design software, tools, instruments, and specialities but 3D CAD modelling is not efficient inability to create 3D instead of Maya, 3DMax,

Sketchup, or any other usual software. They used Revit for 3D computer modelling in this case study, because of easy to render and create a 3D building model.

Planners and Architects are using VR to check all project details with walking through the project, flying around, or using another mode. VR software varies like OpenSceneGraph, Virtools Quest3D, but eventually, every project should hold a unique sequence of coding, in this project, they used the OpenSceneGraph program.

- Methodology:

As shown in the previous part, the Architects need to form the mountain as its natural one in adhering the scale mode to correspond the conceptual design. As this project is complicated in facility detailing modelling the exact terrain with a precise work which consumes more time and effort, instead, they modelled a 3D mountain, scanned, and created by laser technology.

The execution planning running through the steps below:

1) Use the technology of laser scanning to get the coordination points of the mountain.
2) Build up the model by importing the 3D points after digital processing.
3) Combine and optimizing the 3D modelling of a mountain with its entertainment facilities.
4) Integrate the structural drawing that including supports with the 3D mountain model, synchronizing the work together will get better results.
5) In draft planning, the planner consulted to optimize in accordance with the former model of the mountain and integrated facilities.
6) redesign the structure according to the previous model agreement, and revise by structural designers to analyze and compute the loads imposed on the mountain surface and determining the sectional part of the concrete structure.
7) make structural joints and compute the stress after taking targeting area into account, then submit the work.
8) Rendering a 3D steel model after calculating the loads required.
9) Assemble all parts into BIM model including the locality to make sure all will fit together, therefore, no deviation occurs, as a reference, all BIM and VR models have submitted to all users of the project.

- Project processes:

The process is starting after submitting the surface model of iceberg then digitizing the mountain model by laser scanner to acquire the three-dimensional point clouds. The scanner flings laser to define 3D coordinated objects by measuring the reflected rays of the surface. Moreover, the scanner is going to render it to enhance the view and be more identical to the reality, as more coordination it defines as more accuracy in the model it shows.

There had been some problems in solving the scanning application process; the tremendous of point clouds is more enough of required data, the cave blocked out laser range to reach what inside. Eventually, they used good software in this project called Geomagic software. It tackled the interior side of the cave with digital shape processing and creating a model of polygonal surface.

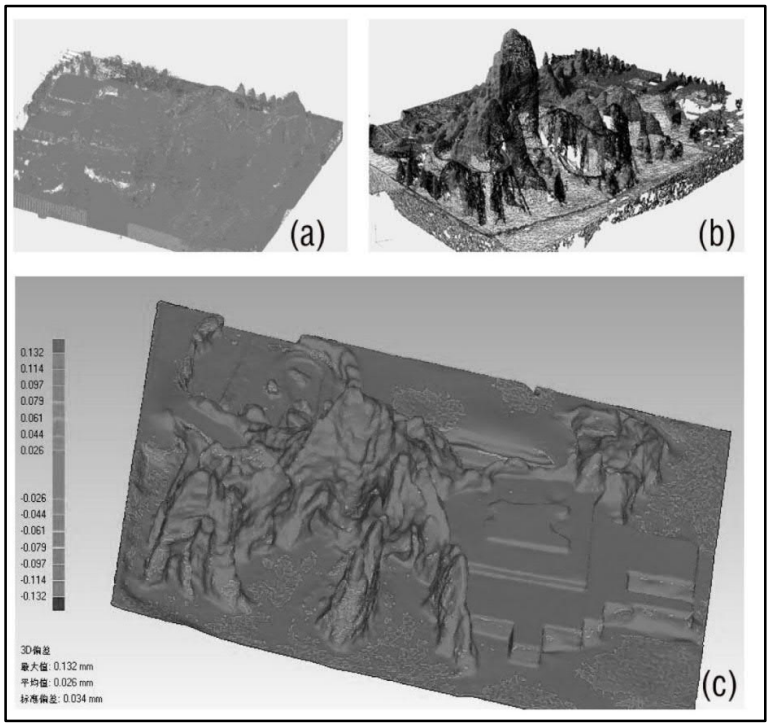

Fig. 35: Processing of point cloud. Source: (Wang, 2013).

The illustration of each figure above as follows:

a) The point cloud is taken by a laser scanner in DWG format.
b) Processing of geographic point cloud.
c) combined analysis.

The steel and concrete parts were modelled in 3D Revit model and assembled with previous models to generate a single model considered all parametric amendments, all this to minimize the incoherence mistakes.

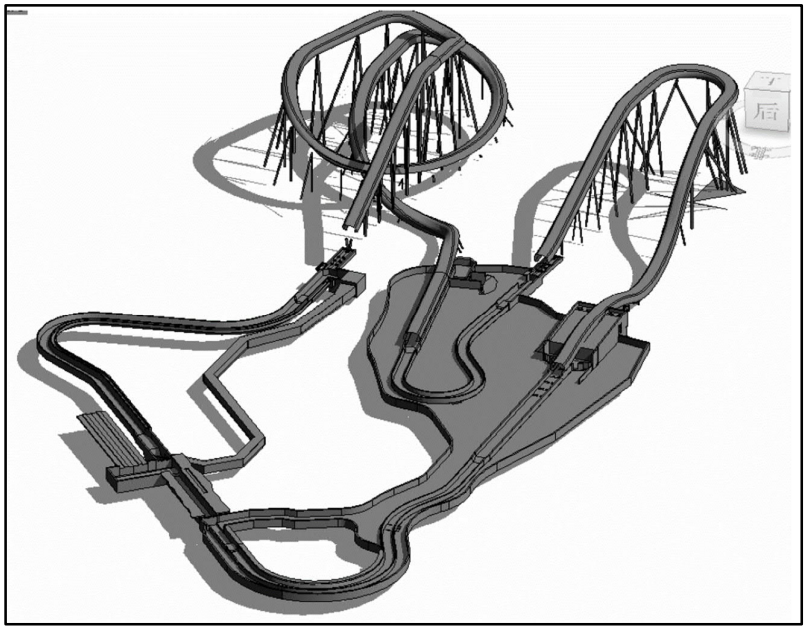

Fig. 36: Create a roller coaster in Revit software. Source: (Wang, 2013).

Next step is to integrate the amusement facility, mountain model, and the Roller Coaster model and find out the clashes and solve it. What makes it easy to find any clashing, is the application of Autodesk software (Revit) having all elevations, plans, and section views. It can be created in automatic mode, as well as any changing will be applied to all views via parametric facts.

In the meantime, the users examined any conflicts in the model between equipment and structure. Also, holding discussions and amendments in the 3D model of BIM files.

Now the project works can be completed with VR BIM software, and users can dispense with working dependently.

Fig. 37: Footages of a combined model of the project taken from VrApp software. Source: (Wang, 2013).

To estimate the cost of VR development, many websites offer a rough calculation based on which features require. For instance, when using a mobile system of Android platform and Gear VR headset running by Unity engine for Roller Coaster scene in basic quality 3D model, the price is starting at 12311 € (Thinkmobile, 2020).

In the end, users discover some features in VR driving mode, like setting the allowable speed to comfort the roller coaster users, to check for closing objects which may threaten users lives, including necessary analysis required in the virtual-mode scenario. By encoding via C sharp (Visual studio program), the programmer can set speedometer preview into the view out displaying, also set a speed limitation to warn when it exceeds the critical or design speed, but this act as video games somehow, it needs other programmes involvement.

The important factors shown on the output result of combining to Unity 3D are might be the speed rate, the cart acceleration, the superelevation gauge, some structural part can be included, for instance, the load in dynamic mode impacts on the wheels.

Furthermore, the data from AutoCAD Civil 3D gives the design speed of roller coaster, the required superelevation considered to VS software encoding system afterwards.

In S&H part, the running mode can attach a function to warn if combining all functions above together in a point would likely to endanger or mode maintenance in this part.

That is happening by having sound affection or light attraction to warn users that this part is structurally unsafe.

Fig. 38: Driving in VR mode after encoding the speedometer. Source: (Wang, 2013).

6. Result and Discussion

6.1 Case studies key findings

In a case study (1), the idea of this project is ready to apply in real-world environment one we noticed the best option for tracking and detecting the construction project is using AR on the tablet, PC or mobile, this will make an estimation for work on-site according to the suggested schedule of the phase.

Unity program is the dominated program in the first case study which utilizes the use of technology such as 3D modelling and BIM which are commonly used nowadays to proceed planning, in addition, virtual technology is making a framework of project management by using Vuforia and C # scripting programmes within Command-Line surface (CS) format that generated by Vuforia, the script is encoding according to the requirement needed to show on the device output.

In the first case study, the planning was not expensive to use a virtual technology scenario, it decides based on the functional element increment, the most important elements shown on the screen are cost, time, and it can include the number of labours that all three constrain elements managed by project managers. In any project, (cost estimate, labours income, materials) are the elements which considered when encoding by C # script, those elements are presented in the end to project manager and stakeholder devices.

In a case study (2) the ability to manipulate the vision outlook and set a basic-related project is one of most technology features which give users bonus in business marketing and client attraction. Visual functions of BIM-VR technology can be used to direct engineering design and project execution, which is important for the collaboration and integration between project stakeholders. Seamless cooperation was of crucial importance as members of this project involved international service firms, architect's office, two local design institutes and a landscape architect office.

The entire design was incorporated into a shared building knowledge model and 3D visualization framework in order to intuitively represent the contradictions among buildings and infrastructure, equipment and materials, so all participants were able to immediately verify and identify the problem accurately.

They could change errors in a timely manner, reduce errors and prevent waste during implementation. BIM and VR technologies above all can have a beneficial impact in the design and execution of complex engineering projects. It will soon become more common and commonly used for the design, management, and execution of projects.

If we consider imposing the Unity and visual studio on this case study, it could be easy to define the level of desired entertainment and drive as a seater of a roller coaster and see around. In result, suggestions to change such as close objects to the running path, the required superelevation can be roughly observed during the driving mode.

7. Conclusion

Instead of mock-ups and physical prototypes, visualization can indirectly save time, as well as enhancing collaboration between users and designers help in the design stages and understand planned future assembly work. Visualization also proved useful when designing a new model for a plant. It is possible to use 3D-dimensional photographs and animations to imagine the plant layout and output flows inside the plant and thus help to develop a common language among employees.

One of the key concepts of using applications and programs such as Autodesk software (Revit, CAD) in construction is to visualize and synchronize construction work with scheduling, and use the visualization process, combining them all together to work together is called 4D tools (3D model + scheduling)-usually scheduling by Gantt method-and this is explained in detail in management.

Visual 4D Simulation also incorporates planning and control moreover, it includes critical functions to assist the team participants in communication. Visual Simulation allows the user to enter outlined comments directly on a picture of the 4D model using techniques such as scripting then submit it as an image to team participants via e-mail.

A regular project report can be created into Microsoft Scheduling program for any date during the 4D construction simulation, including a 4D image, a list of task results or resources on that day, as well as a set of tasks accomplished or hasn't been begun by that day. The 4D simulation will automatically replay or rewind.

BIM is playing a significant role in any process of projects used with AR/VR mode, including CAD software which uses as auxiliary to help in simplifying parametric equations. Laser-scanned technology is one of the digital technologies that important role in generating a complicated model accurately. It had used to cut off waste time in surveying the terrain, on the other hand, many conflictions caused by incomparability issues, leaving behind mismatching in real-time information.

Microsoft Visual Studio IDE features can help to fix the code to adequate the style setting of the project, to simplify and shorten the actions it needs more time to process with respect to not mess up the behaviour of the project.

Unity and VS are consistent with each other to tackle and create all elements need into the project. Also, Prospect is a programme that can Solve construction disagreements to keep projects virtually on budget.

AR and VR can provide a sort of MR

Prospect program simplifies the delivery of VR process, it is a benefit to use in management part and disagreement conflictions, it assists users to collaborate in the design process and strengthen their role as technology leaders, it plays an important role in management part.

Furthermore, VR and AR in management field can approximately diminish quarter of the money and over one tenth of the time is wasted due to processing in sketch planning or either incorrect transfer or timing consumed during the concept or design to target the actual goal on time.

During the market volatility incepted with Coronavirus pandemic, it is a risk to start investing in a land without having a feasibility study, one of this study is planning management process, it is an effective domain when using virtual technology.

VA option allows moving parts of a 3D model, showing any collisions and even capturing a path to rebuild for more study. This is a perfect approach for sessions of project analysis, maintenance, and preparation.

VR can be a powerful tool for assessing and validating new ideas and products, shortcomings time and cost product reduction. Only big firms nowadays utilize virtual technology and profit from its competitive advantages.

DPR is a division of professional regulation for a professional contracting business with a passion for performance, good cooperation in managements, trust, experience. VR is a large-scale project execution technology in their section which meets the requirements specified in the project's documents, detailing the results and observations of the VR program applied to many construction projects in DPR, and this is a point which makes VR-enabled companies be attractive to clients. Also answering all question-related VR observation and result such as:

- Are there appropriate workspaces?
- Am I feeling comfortable when involving in this space?
- Is there visual distortion?

- Is accessibility protected and safety-compliant?
- Can the prefabricated components be more securely installed on the equipment to better suit the characteristics of the surrounding elements?

Virtual technologies have been used in (CEET) platform to assist all problems in delivering appropriate instruction to workers and in implementing the safety management program as required. It classifies VR technologies into five main types on basis of the visualization usage and used platform displayer, those include VR immersive, 3D VR games, BIM-VR, and AR. The goal is to create a virtual on-site environment, especially when building towers and high-rise buildings, to take into considerable concern and to test the safety of the worker and to ensure that the training about hazardous risk is successfully completed.

In the DM part, AR smartphones allow people to use BIM models to view specific types of projects. Through this, the staff at the early stage of the construction worksite can quickly and effectively verify the outcome of the job, thereby avoiding inattention that causes errors. DM-AR tools for expanding decision-based knowledge of BIM geometry. They can either view the AR-BIM Geometry material overlaid on real-site elements, as this allows site managers and inspectors to track the condition of RC's job, and quickly find any inaccuracies.

In case study one, the combination of models became unified in one frame to compassing technology solution, from input real cost of material to have a sort of scheduling simulation which afterwards gather all to point out a BIM-VR enabled framework, can manipulate in changing of input elements that PM always in relying on it. In addition, the layers control of VR mode in Prospect software ease managers to pick up the field-related works only.

The participants conceptually defined AR's potential in the construction sector as it is user-friendly, and this is a tool that can be used to visualize complex information source throughout the field. AR also allows for greater coordination among project stakeholders. Workers may use AR to imagine site orders, materials needed and workflows. The feedback received about the present work was that the method under discussion can:

- Reduce the description time of the information.
- Decreases building time.
- Minimize mistakes compared to paperwork updates.

- Increase project stakeholders' satisfaction by promoting the visualization of information

In comparison, it has been suggested to:

- Incorporate into one program the whole system.
- Boost the "BIM-Phase loop" model rendered.

The delay time in upgrading the timetable and the "BIM-Phase net" can be solved.

In the case study (2) we can compile Unity and VS; it might be easy to define and see around the level of desired amusement and drive as a seater of a roller coaster. Therefore, suggestions for adjusting, such as close objects to the running road, will roughly observe the necessary superelevation during the driving mode.

Recent simulation studies using VR and AR are however still some construction work procedures and operations. Simulation using the VR and AR could also be expensive. Thus, they are only used as additional approaches for other techniques to improve the impact on the construction improvement process and to make precise planning prior to the actual construction.

7.1 Answers of investigative questions

- What is the possibility to influence the rate of the company’s budget by using a visualization technique?

The possibility is noticeably high when uses virtual technology and sophisticated programmes in the project especially, the complicated process projects which often loos more time and money. Also, virtual planning management can ease the process and jump to the next one in a short time.

- How could it be useful in marketing?

The most enjoyable and attractive thing is to deliver the product virtually and set up large requirements and providing them through a mobile app that makes AR marketing more entertainingly useful.

- How can Virtual reality impacts on real estate?

VR helps real estate firms to sell the completed project prior to completion of construction. The technology enables sellers to view both the exterior and interior of unbuilt assets and let purchasers explore a place from the sitting at home.

- What could VR, and AR influence into supplies (income labours, cost, project duration)?

The developed systems and software that generates models in 3D, 4D (time) and 5D (budget/cost) is enabling simulation and coordination in the late design phase of what will be executed and monitored, enabling better collaboration between working teams and better understanding.

Devoted (VS) tools now require the incorporation of multiple models, and schedule data to connect smart objects to individual resource-loaded and logic-linked activities. Using 4D can increase planning process performance in several ways.

The Gantt program usually aims to combine both together to function alongside the so-called 4D tools (3D model + scheduling), and both can be installed inside GIS using the database management method to support the planning field by preserving the construction complement data.

VR can make proactive scheduling

- How can the project be simulated in AR mode and the foreseen presumption for the project timeline?

By using advanced software and consistence with C Sharp programmes, users can encode scripts show the required output needed in the project.

- What is/are the relationship(s) between BIM and VR and to what extent can BIM and VR be integrated using platforms to earn benefits?

Users can join the BIM datum in an immersive visual environment and manipulate factor analysis such as material type and cost that effectively renders a production design as in real-time mode. It can extend to model the project, detect clashes, and having decision-making tools.

Declaration of Authorship

I hereby declare that the attached master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

30th October 2020

Location, Date

Signature of the student

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