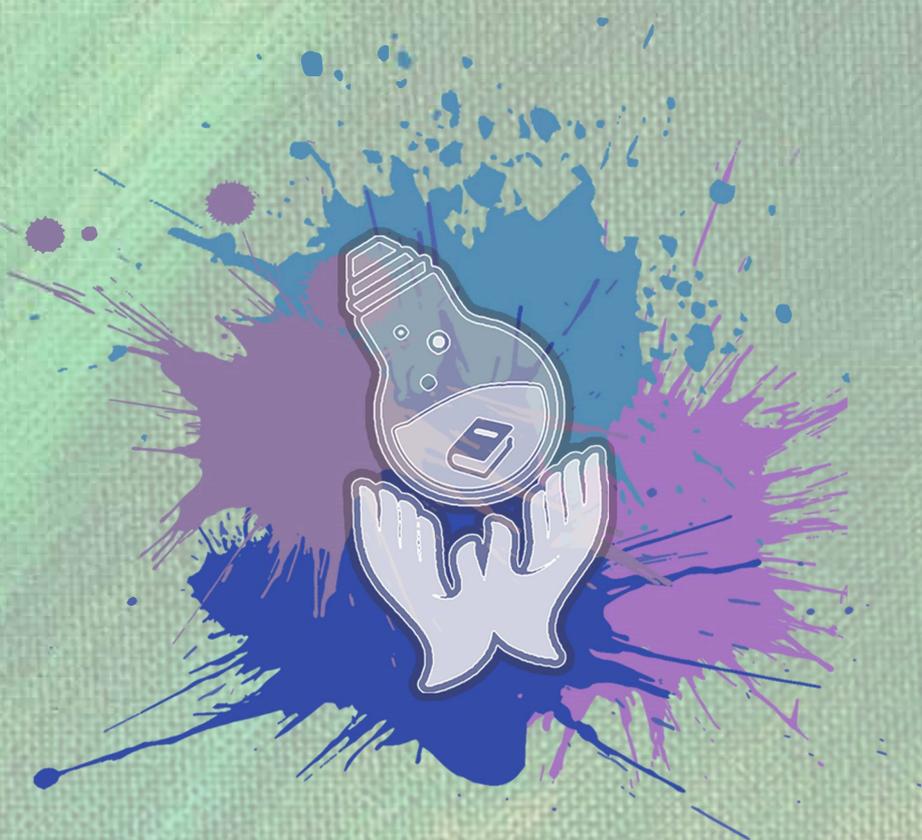




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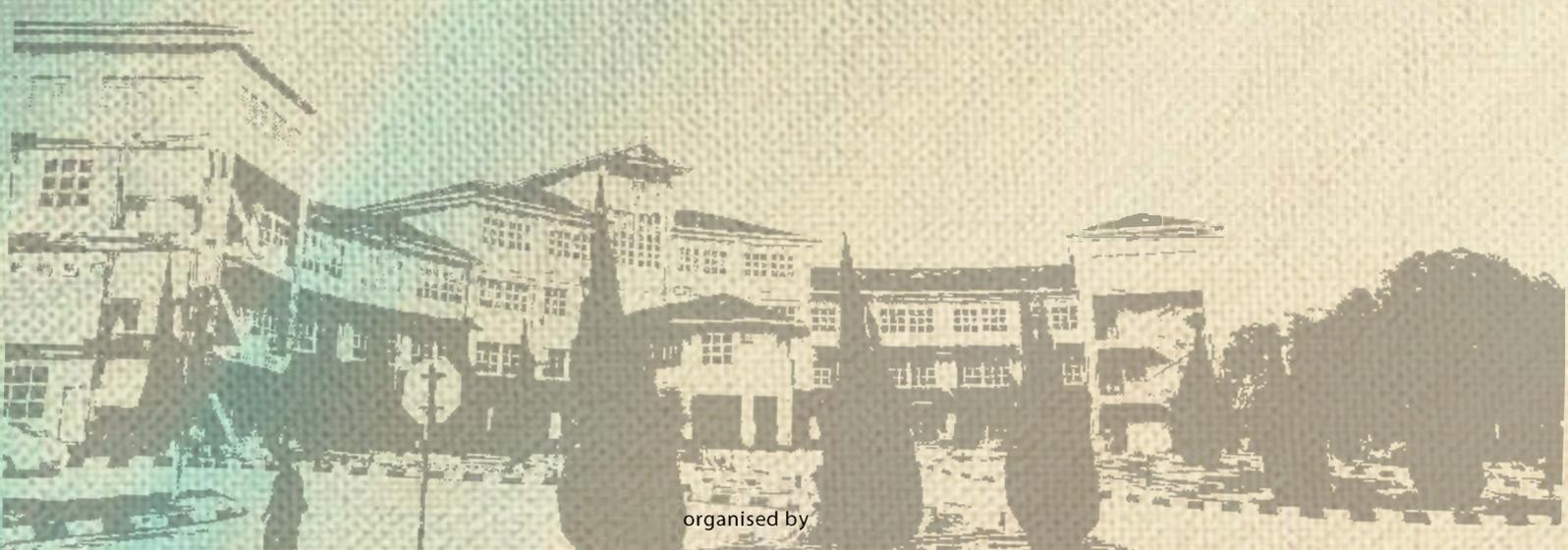


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SERI ISKANDAR CAMPUS

AUGMENTED REALITY (AR) GLASSES FOR INSPECTION OF STEEL FORMWORK SYSTEM

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Abstract:

Emergence of information technology (IT) in recent years has urge construction industry to adapt with the current Industrial Revolution (IR) 4.0. Aligned with technological advancement, Industrialized Building System (IBS) has long commercialized in Malaysia that affects broad usage of Steel Formwork System. Despite the advantages, problems continue to occur during the system's assembly and inspection since man-efficiency remain in the current practice. Presently, robotics system is common to assist human in operating jobs. Along with technology and robotic revolution, Augmented Reality (AR) appears to be practical in most field as a potential reduction of errors. Desk study will be conducted in finding relevant research regarding AR technology as the solution to the identified problems. The expected findings of the study are to be able to identify the concurrent problems in the inspection of the system, determine AR concept and propose a solution to the problems. Derived from AR technology, a wearable instrument known by the name AR Glasses for Inspection of Steel Formwork System is proposed. The proposal shall contribute to problem rectification of inspection works for Steel Formwork System as well as providing possible implementation of advance technology in construction field.

Keywords:

Industrial revolution; construction; Steel Formwork System; technology; Augmented Reality.

1.0 INTRODUCTION

Industrial Revolution (IR) 4.0 is now focusing on Internet of Things, Data and Services. Hence, construction field has enhanced Industrialized Building System (IBS) to stand tall. Despite the advantages of the system, problems still occur during assembling of the components that relates to inspection. Highest Malaysian construction fatality is from high-rise, in which often with the aid of IBS, the steel formwork system. Currently, manual inspection is used, where inspection level varies between people. Augmented Reality (AR) allows construction projects to be inspected in terms of parallelism of the intended design and the actual performed work, making the foresaid problems potentially solvable. Moreover, performance of AR may lead to a better supervision and wholly benefits the admiration of construction industry along with the Construction Industry Transformation Programme 2016-2020 (CITP) agenda. Therefore, a study is conducted focusing on three objectives. Firstly, the study is to identify current problems in the system inspection. Secondly, the study is to determine AR concept and possible integration in construction. Lastly, the study is to propose a wearable gear with AR integration.

2.0 LITERATURE REVIEW

Literature review has been done for the definition of AR technology, arising issues in IBS, various approaches and inspection guidelines. Desk study on AR-Building Information Modelling (BIM) integration in robotics and the potential implementation of AR technology is also done for the purpose of the study.

AR is the concept through utilization of combined real-life visualization and Virtual Reality (VR) simulation (Kivrak et. al, 2013). AR technology may compose into wearable robotics and mobile computerized device. Formwork is one of construction problems and the failure may be due to human error (Yates and Lockley, 2002). Currently, manual inspection is used, where standard of inspection level varies for every people, as a man is impossible to not make any mistake at a time. Missing

hardware, improper tying and improperly connected hardware are some highlighted major causes of the formwork system breakout, whereas the term “hardware” refers to panels.

In Malaysia, Quality Assessment System in Construction (QLASSIC) is used as a workmanship’s quality assessment (QA) system based on guideline in Construction Industry Standard (CIS) 7:2014 (CIDB Malaysia, 2017). In order to eliminate errors caused by human, robots have been used in the current production. IBS manufacturers have also practice Computer Integrated Manufacturing (CIM) for product’s QA (Yamazaki, 2004). Currently, manual inspection is done for Steel Formwork System based on CIS 7: 2014. The standard requires man-empowerment (CIDB Malaysia, 2017), where the practice may contribute to human error. The proposed AR Glasses shall comprise incorporation of CIS 7:2014 guideline aside with BIM being the main design reference for every inspection in a project.

Inspection robotics have globally evolved from wall-climbing robots in the 1990s, drones in 2013 to AR devices in the present day. BIM provides virtual 3D model of design, the concept is diffusible to AR operation where the BIM model is able for augmenting display in real-world time with combined integration (Kivrak et. al, 2013). According to Pejic (2014), AR has been used in construction in civil engineering and architecture. The AR technology is also used for mechanical and electrical (M&E) inspection and outdoor viewing of building and steel structures (Pejic et. al, 2014). Having existing AR application present, the proposal is potential to be implemented in Malaysian’s construction inspection in a form of integration of advanced technology with robotics.

3.0 METHODOLOGY

Literature review on related and relevant researches is done via data collection of qualitative research, in which, the method used is desk study. The collected data is then analyzed by the means of comparative analysis, whereas the expected result is to propose a novel innovation idea that is the AR Glasses.

4.0 ANALYSIS AND FINDINGS

4.1 Issues and problems in the inspection of Steel Formwork System

Missing hardware, improper tying and improperly connected hardware are some of the highlighted major causes of the formwork system breakout. Missing hardware refers to panels or pieces of the IBS formwork being overlooked of its placement and location, causing the incompleteness of formwork assembly. Improper tying refers to the use of wrong size tie or those that is in unintended manner, which could cause offsetting of formwork. Improperly connected hardware or improper shuttering (Rakesh and Ilango, 2015) is wrongly connected panels due to misidentifying of formwork pieces.

4.2 Concept of AR technology

The utilization of AR technology concept seems to benefit in efficiency, precision and accuracy, as well as eliminating problems in inspection of Steel Formwork System assembly. Existence of AR within Google Glass and Virtual Reality (VR) headsets in markets (Karl et. al, 2018) has inspired the concept of the innovation idea. BIM and AR are aimed to be integrated in the development of the AR Glasses.

4.3 Marketed AR Smart Glasses

Parameters to evaluate distant existing product of AR Smart Glasses (ARSG) are in terms of price, battery power and life, weight, field of view (FOV), camera, Open Application Program Interface (API), audio, sensors, control medium, processors, storage, memory and Wi-Fi connectivity (Syberfeldt et. al, 2017). Despite the variation in features, other concept of the Glasses can be analyzed for most of the similarity as in Table 4.1.

Table 1: Comparison of ARSG products in market (Syberfeldt et. al, 2017)

ARSG	Price (RM)	Battery life	FOV	Optics	Camera	Sensors	Processors	Storage & Memory
Epson Moverio BT-300	3269.85	6 hours	Binocular 20°horizontal 11°vertical 23°diagonal	Optical see-through, 24-bit HD	5MP, 720p	Geomagnetic Accelerometer Gyroscopic Ambient light	Intel Atom *5 (1.4GHz) quad-core	16-GB internal, Micro-SDHC 32GB, 2GB RAM
Racot Jet	2094.55	4 hours with external battery	Monocular 15°horizontal 8.5°vertical 17.2°diagonal	Video see-through, HD display	1.2MP, 720p, 30EPS	3-axis gyroscopic, compass & accelerometer, GPS, IR	ARM Cortex, (1 GHz), dual core	8GB Flash, 1GB RAM
Optinvent ORA-2	2934.05	3 hours with external battery	Monocular 20°horizontal 12°vertical 23°diagonal	Optical see-through, 24-bit HD	5MP, 720p, 30FPS	3-axis gyroscopic, compass & accelerometer, GPS	OMAP (1.2GHz), dual core 32-bit	4GB Flash, Micro-SDHC 32GB, 1GB RAM

4.4 Acceptance of AR technology

A total of 140 respondents were asked on AR potential implementation was conducted in March 2018. The Bar graph in Figure 1 shows that acceptance is dominant rather than poor reluctant embracement.

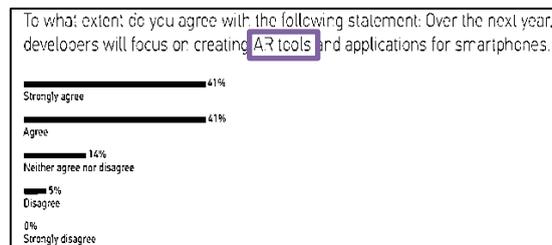


Figure 1: Opinion on the acceptance of AR technology
Source: (Karl et. al, 2018)

4.5 Proposal of AR Glasses for Steel Formwork System Inspection

After considering the AR concept, the slightly similar marketed products and the potential implementation of AR technology, AR Glasses is proposed to assist the construction inspection. The proposal shall be the AR Glasses for inspection of Steel Formwork System (Figure 2).

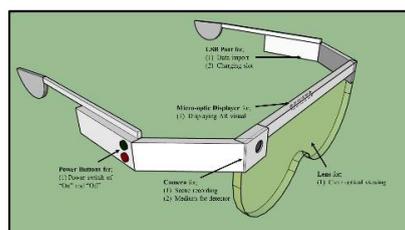


Figure 2: Prototype of AR Glasses for Inspection of Steel Formwork System

5.0 CONCLUSION

Even though human is the creator of automation and technology, man empowerment is unbearable to wholly conduct perfect surveillance. Therefore, inspection is better done with AR technology, as full observation is achievable in shorter time minus the human errors with the aid of the AR Glasses.

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