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E-PROCEEDING OF

1st INTERNATIONAL E-CONFERENCE ON GREEN & SAFE CITIES 2022

"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

20 & 21 SEPTEMBER 2022

Organisers:

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ORGANISED BY

Gresafe_Cities RIG
The University of Queensland, Australia
Kampus Hijau UiTM Perak

CO-ORGANISED BY

Research, Industrial Linkages, Community & Alumni Network (PJIM&A)

Perpustakaan Negara Malaysia Cataloguing in Publication Data

No e ISBN: 978-967-2776-13-0

Cover Design: Muhammad Falihin Jasmi

Typesetting : Ts Dr Azizah Md Ajis

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SMART TECHNOLOGIES (ST) APPLICATION IN IDENTIFYING MOULD GROWTH DEFECTS IN DEFECT MANAGEMENT WORKS FOR OPERATED HERITAGE BUILDINGS IN PENANG, MALAYSIA – A PILOT SURVEY

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Abstract

In Malaysia, there are many heritage buildings that are still in operation and are heavily affected by mould growth defects due to high moisture content, poor air circulation, and other factors that lead to the degradation and dilapidation of these buildings. Through government bodies and related agencies, defects in heritage buildings are still maintained with certain procedures which consist of generic documentation. However, these procedures are still operated in a conventional way and lacking with smart technologies application that will be able to identify the related defect in a more precise and high-tech approach for these heritage buildings. In conjunction with the Fourth Industrial Revolution (IR 4.0) and Sustainable Development Goals (SDG), it is significant to improvise current defect management works with Smart Technology (ST) applications. Therefore, this research focuses on exploring the significant ST applications that can identify the mould growth defects inside heritage buildings in a more precise approach. Through preliminary study, it will focus on heritage buildings with mould growth issues in Penang to formulate a significant defect management work that can be integrated with ST applications. This paper will present the results from a preliminary survey conducted with experts who have suggested suitable ST applications to identify mould growth defects in a selected case study in Penang. The pilot survey shows that virtual reality (VR) is the best Smart technologies that can be integrated with defect management works in order to identify mould growth issues. The research will provide relevant insights from this panel of experts through a purposive sampling approach to help the government or local council to establish a more sustainable heritage building.

Keywords*: Defect Management, Mould Growth, Smart Technologies Application, Operated Heritage Buildings.*

INTRODUCTION

Like any other heritage buildings in Malaysia, building defects are common issues that affect the building structures and elements and shorten the buildings' lifespan (Alauddin et al., 2018). Ismail (2015) identifies common defects in heritage buildings: condensation, stretching, crack, installation error, pest attack, bending, sagging, leaks, distortion, rust, exfoliation, clogging, and moulding. In a study by Hanafi et al. (2018), the apparent defect found inside heritage buildings is mould growth and dampness.

Many heritage buildings in Penang, Malaysia, are affected by mould growth and dampness defects are considered the most challenging defects (Noor et al., 2019). Both dampness and mould growth are related to each other when there is moisture from the dampness inside the material; it will find a way to the building wall, which leads to mould growth.

Currently, the defect inside heritage buildings in Malaysia is being maintained by government bodies, related agencies and professional bodies (Alauddin et al., 2017). But the process of identifying of the defects is still practised conventionally by using generic documentation through a specific management process (Noor, 2019). However, the defect management works still do not find significant ST related to managing the mould growth inside heritage buildings. Smart technologies (ST) is a Smart technology that combines massive data analysis, machine learning, and artificial intelligence to give inanimate objects cognitive understanding (Thakur, 2022).

This paper is focused on the significance of ST applications in identifying mould growth defects in heritage buildings in Penang, Malaysia. This paper also discusses the pilot survey conducted with the panel of experts who have suggested suitable ST applications to identify mould growth issues in a selected case study in Penang.

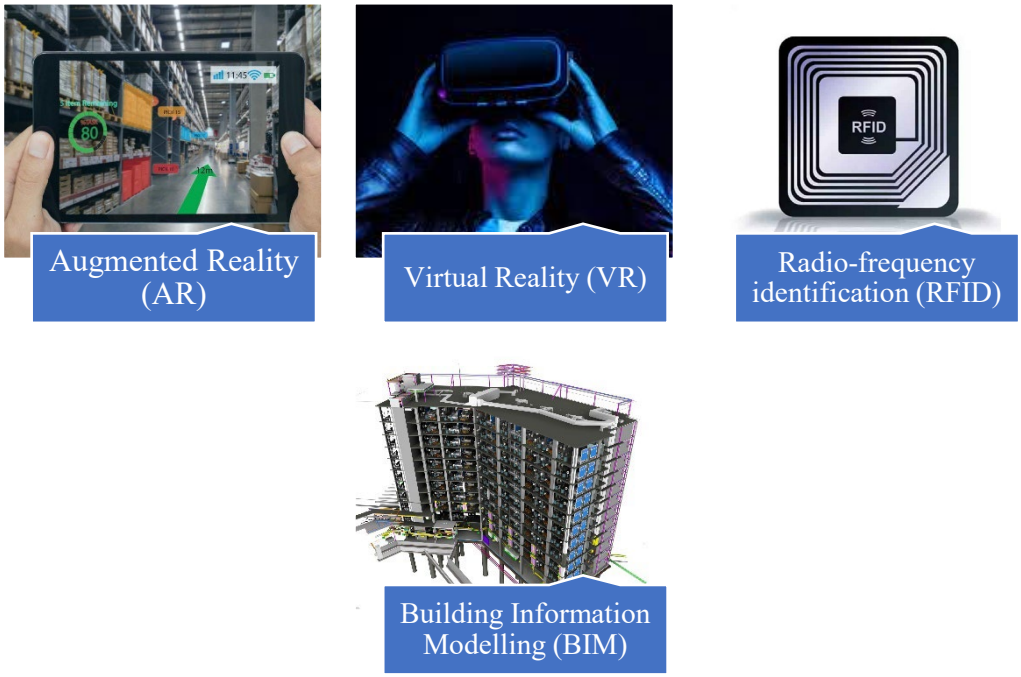
LITERATURE REVIEW

Smart Technologies Application

The fourth industrial revolution (IR 4.0) is on the horizon as a key driver in increasing the economy and promoting technology innovations. Ibrahim et al. (2021) explained that prior communications between users and technology could be centralized and automated with smart technologies. Other than, that green technologies also can be integrated if it towards to Smart Technologies. Ibrahim et al. (2021) also listed several types of smart technology that can be implemented, which are Building Information System (BIM), Smart Communication, Big Data, Sensor, RFID, Augmented Reality (AR), Remote Operations and Locations Services. In hopes of promoting smart technologies, new technologies are used: Augmented Reality (AR) and Virtual Reality (VR).

Figure 1

Several types of Smart Technologies



From previous research, Augmented Reality (AR) and Virtual Reality (VR) use in architecture, engineering and construction would benefit projects with accelerated working site training and safety, design development and communication between parties (Behzadi, 2016). Currently, there is a gap in defect management works where the smart technologies are still limited because of a lack of exposure, expertise and policy (Chan et al., 2017; Kordi et al., 2017; Yee et al., 2020).

There are several types of research that show the implementation of smart technologies on heritage buildings for defect identifications. For example, a case study in Malaysia which used unmanned aerial vehicle (UAV) or drone for visual inspection for a dilapidation survey on a heritage mosque in Melaka (Sauti et al., 2018). But still very vague area on smart technologies for heritage has not been explored yet on identifying could growth defects.

The adoption of smart technologies in defect management brings many positive impacts that improve the defect process's efficiency, decrease defect activity on-site and reduce the dependency on conventional electricity.

Defect Management Works Practice in Heritage Buildings

Defect management on heritage buildings in Malaysia is essential to mitigate the defect issues that occur inside the buildings. Defect management has already been established in several sectors in managing the construction defect (Isa, 2014; Lin et al., 2016), facility management (Hasnan et al., 2018), and heritage buildings (Alauddin et al., 2016). Isa (2014) researched defect management in hospital buildings by learning and tracking the defects to minimise the defects in future projects. Isa (2014) also explains that tracking defects their roots cause will avoid defects occurring in the buildings.

At the moment, defect management works for heritage buildings are still using the conventional procedure and generic documentation. Noor et al., (2019) stated that defects in heritage buildings are maintained conventionally by recording, data collection and documentation. Kammin et al., (2017) align with Noor et al., (2019) statement that photography and documentation are the general process of defect mitigation on heritage buildings.

Other than that, defect management practices by government bodies and related agencies are still linked with dilapidation surveys using the Non-Destructive Test (NDT) and Building Condition and Analysis (BARIS) (Nor, 2018). The Department National Heritage Malaysia defect process is nominated by professional bodies or expert individuals, such as Building Surveyors, Engineers, or others, to inspect the heritage buildings. This shows that defect management works for heritage buildings are still dependent on typical procedure and documentation, but not on ST.

The Description of Heritage Buildings in Penang

Definition of the heritage building is a heritage site, heritage object, underwater cultural heritage or any living person declared as National Heritage (National Heritage Act, 2005). In Malaysia, two cities have been recognised by UNESCO (United Nations Educational, Scientific and Cultural Organization) as World Heritage Sites in 2008, which are Melaka and George Town. This recognition has helped the heritage site and buildings in the cities still retained today.

Every heritage building is different to each other because it depends on the local materials and the tropical climate of Malaysia. Typical heritage buildings are built from bricks, timber, rock, granite, and lime (GTWHI, 2020). This statement is supported by Ng (2017), stating that most building materials are made from stone, limestone, clay, timber, and metal. Most materials are taken from local sources to reflect the tropical climate.

Penang was selected for this study due to its history, location, materials of buildings, and layout of heritage buildings. The Heritage Management Plan (2008) stated that there are 4649 total heritage buildings in Georgetown that have been identified by Majlis Perbandaran Pulau Pinang (MPPP) or Majlis Bandaraya Pulau Pinang (MBPP). A new study by Ghazali et al. (2022), in conjunction with MBPP, states that Penang has 4336 total heritage buildings. Penang has its bodies that manage the properties within sites on heritage buildings.

Table 1

List of Heritage buildings in Georgetown, Penang, based on age.

Buildings	Year Built	Year Ages
Municipal Town Hall	1879	149
City Council	1903	119
Penang Immigration Department	1890	132
Lebuh Pantai Fire Brigade Department	1908	114
George Town World Heritage Incorporated (GTWHI)	1920	102

According to the table above, the age of the heritage buildings in Penang is more than 100 years old and above. According to Hanafi et al. (2018), most of the heritage office building's architecture is influenced by British Colonial. Other than that, Hanafi et al. (2018) further explained that most of the heritage buildings are erected by mixing British with Malays, China and India.

METHODOLOGY

Definition of a pilot survey is called a 'feasibility' study (Simkus, 2022). It is also used as a specific pre-testing of research instruments, including questionnaires or interview schedules (Doody & Doody, 2015). Other than that, the pilot survey is conducted before the primary research to evaluate the potential of the future project (Simkus, 2022).

This study has employed the pilot survey research method. Because in order to find the best ST in defect management works. The quantitative data collection technique that consists of closed-ended and open-ended questions was used to collect the data concerning the ST. Nonetheless, the panel of experts are selected through purposive sampling. Based on Cambell et al. (2020), purposive sampling is to see the perspective or view of a specific kind of people that has its view about the idea and issue of the question based on the aims and objective of the study. Miles & Huberman (1994) stated that purposive sampling is a relatively small and purposively selected sample. It is aligned with the research because it focuses on experts in a specific area: heritage buildings, ST and defect management work. Based on previous research by Prihatmanti et al. (2014), a study on several heritage buildings in Penang shows that most buildings have mould growth problems.

Respondent and Sampling Technique

The respondents for this study are the panel of experts in heritage buildings, defective works and smart technologies applications. For this pilot survey, the total number of experts in this pilot survey is six experts persons in different organisations. These experts are focused on the type of ST that can be implemented to identify mould growth inside Penang's heritage buildings. Hence, the respondents completed the questionnaire that had been distributed. The respondent evaluated the questionnaire, which was rated as yes or no.

Table 2

List of experts based on organisations

Organisation	Total
Conservator and any related design background	1
Building Surveyor, Facilities manager and any related area	5

Method of Analysis

The quantitative data from questionnaires will be analysed using statistical analysis using Statistical Package for Social Science (SPSS) software version 26 to perform the data analysis.

Figure 2

Research Design Framework

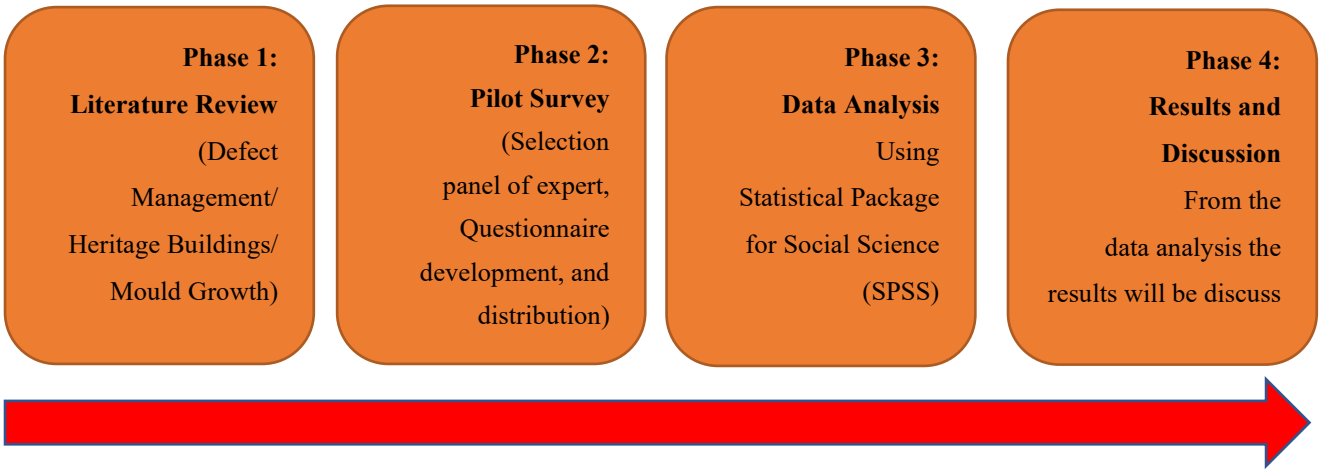


Figure 2 shows the current flow of the research design framework for this paper. The research begins with phase 1, a literature review covering defect management currently used, heritage buildings in Penang, and mould growth issues in heritage building sites. Phase 2 is the pilot survey, selecting a panel of experts, developing the questionnaire and distributing it to the panel of experts. For phase 3 data analysis, the data from questionnaires will be analysed by SPSS. Lastly, phase 4 results and discussion this chapter will discuss the results from the previous phase, data analysis.

RESULTS

Evaluation of the ST on Identifying Mould Growth in Heritage Buildings

Table 3 shows that 50.0 percent of the respondents are from private agencies, 33.3 percent from government agencies and 16.7 percent from institutions. This indicates the majority of the respondents are from private agencies. Analysis of the involvement in defect management works on heritage buildings shows that only 66.7 percent were involved, and 33.3 percent were never involved. This result shows that most of the respondents involved in the defect management work on heritage buildings.

Analysis of respondents' experience in handling defect management work in heritage buildings shows that only 16.7 percent of respondents involved between 0 to 5 years, 16.7 percent between 6 to 10 years and 66.7 percent between 11 to 20 years of experience. This result shows that most respondents are experienced in handling defect management on heritage buildings sites.

For the type of project involved in heritage buildings, 50.0 percent of the respondents carried out the project for the government and 50.0 percent for the private sector. Analysis of ST applications that can be applied to heritage buildings shows that 83.3 percent agree that ST can be applied to defect management work, and 16.7 percent are not sure, but it is possible to explore. This indicated that most respondents agreed that the ST application could be implemented or applied in defect management works to identify the mould growth problem inside the heritage buildings.

Table 3

Demographic Profile of the respondent.

Criteria	Attribute	Defect Severity (Frequency)
Type of organisation		
Institutional	1	16.7
Government Agencies	2	33.3
Private Agencies	3	50.0
Involvement in defect management works Heritage Buildings		
Yes	4	66.7
No	2	33.3
Experience handling defect management works in heritage buildings		
0-5 years	1	16.7
6-10 years	1	16.7
11–20 years	4	66.7
Type project involved in defect management works		
Government Project	3	50.0
Private Project	3	50.0
ST application can be applied in defect management process for Heritage Buildings		
Yes, it can be applied	5	83.3
Not sure, but possible to explore	1	16.7

Table 4 presents overall results from the panel of experts on the type of ST that can identify mould growth issues in heritage buildings. The highest selection upon ST to be implemented in heritage buildings is Virtual Reality (VR), with a mean score of 1.21 from 6 experts panels rating suggested as the most effective ST to be used. The lowest mean score in ST is Augmented Reality (AR) which a 1.24 mean score and Unmanned Aerial Vehicle (UAV), with a 1.59 mean score that is not effective in mould growth identification in heritage buildings.

This shows that with VR application the process of identifying mould growth issues in operated heritage buildings can be significantly improved and efficient. From overall results on ST selection is a 1.34 mean score.

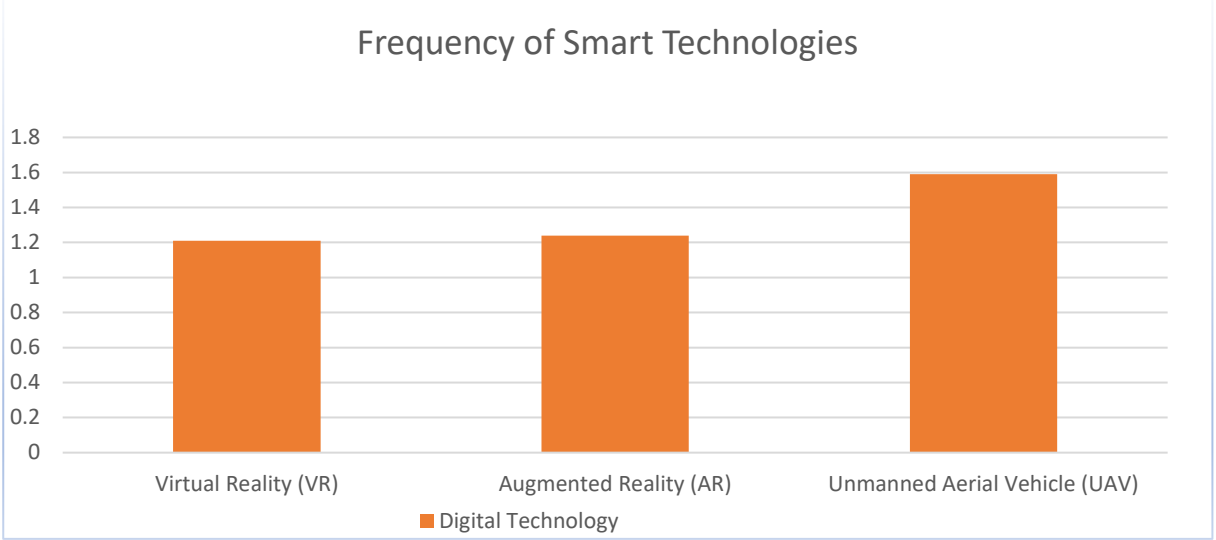
Table 4

Frequency of Smart Technologies for mould growth issues identification in heritage buildings.

Smart Technologies	Attribute	Building (Frequency)				Fabric			MD
		IW	C	CE	WD	F	R	CR	
Smart Technologies	Virtual Reality (VR)	5	5	5	5	4	5	4	1.21
	Augmented Reality (AR)	4	5	4	4	5	5	5	1.24
	Unmanned Aerial Vehicle (UAV)	2	3	1	3	2	4	2	1.59
	Overall Mean								1.34

Figure 3

Frequency of Smart Technologies for mould growth issues identification in heritage buildings



The results from table 4 and figure 2 show that the overall mean for all ST based on elements of buildings shows that using virtual reality (VR) can significantly impact the identification of mould growth issues in heritage buildings. In order words, defect management works with the implementation of ST. It can improve the efficiency in identifying mould growth and manage the mould growth issues inside heritage buildings. As for the type of ST, most respondents agreed that ST implementation in defect management works could be applied.

CONCLUSION

The findings have justified the implementation of ST in defect management works for mould growth identification for heritage buildings in Malaysia. Although the mould growth issues inside heritage buildings are a common threat, ST can improve the process of defect management works. The results from the experts show that virtual reality (VR) is the best ST for defect practice. This pilot survey results will be explored in the actual case study to understand the best ST to implement defect management in Malaysian heritage buildings. The future case study will focus on Malaysian heritage buildings that are heavily affected by mould growth issues to understand the current condition of buildings and ST that can be applied. In this case, the government should continuously implement ST for defect management works to identify mould growth issues inside the heritage buildings.

ACKNOWLEDGEMENT

The author would like to thank the Department of Built Environment Studies and Technology, Universiti Teknologi MARA (UiTM) Perak Branch, Seri Iskandar Campus for the support and motivation of this research.

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