Faculty of Information and Communication Technology

ENHANCED SNAPSHOT WITH INTELLIGENT OPTIMAL REPLACEMENT MODEL FOR HOSTEL MAINTENANCE MANAGEMENT BASED ON FAILURE DATA

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DECLARATION

I declare that this thesis entitle "Enhanced Snapshot Model with Intelligent Optimal Replacement Model For Hostel Maintenance Management Based on Failure Data is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………………………

Name : YUSENI BIN AB WAHAB

Date : ……………………………………………

APPROVAL

hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of Doctor of Philosophy.

Signature :..

Supervisor Name : ASSOC. PROF. DR ABD SAMAD BIN BASARI

Date : ....

DEDICATION

Dear Allah

I devoted my life and death to You, Allah. May my life is within your guidance.

My Parent

(Hj Ab Wahab bin Abdullah)

Thank you for your sacrifice and love. No such compensate except from Allah.

My Beloved Wife

(Hairul Hazlina bte Mohd Ali)

Your support, patience and encouragement give me strength to finish this study. May Allah bless us.

My Supervisors

(Assoc. Prof. Dr Abd Samad bin Hasan Basari),**(Professor Dr. Burairah bin Hussin)**

Thank you for all the knowledge. May your knowledge are beneficial and useful for all humanity.

My Siblings

Thank you for your support and love. May Allah forgive us.

My Children

(Nur Adrina Batrisyia bte Yuseni)

(Nur Qaisara Khairina bte Yuseni)

(Mohammad Fareez Azeem bin Yuseni)

May Allah guide and protect us to be good Muslim

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LIST OF ABBREVIATIONS AND GLOSSARY

ACO – Ant Colony Optimizing

AHP – Analytical Hierarchy Process

AI – Artificial Intelligent

CA – Criticality Analysis

CI – Consistency Index

CM – Corrective Maintenance

CMMS – Computerised Maintenance Management System

CR – Consistency Ratio

CR – Redesign

D – Detection

DB – Detection Based

DMG – Decision Making Grid

ELSP – Economic Lot Scheduling Problem

EMQ – Economic Manufacturing Quantity

EPQ – Economic Production Quantity

ESM – Enhanced Snapshot Model

FMEA – Failure Mode and Effect Analysis

FMECA – Failure Mode, Effect and Criticality Analysis

FLRB – Fuzzy Logic Rule Based

FTD – Failure Time Distribution

GA – Genetic Algorithms

GACO – Genetic Ant Colony Optimization

HEI's – Higher Education Institution's

HFM – Hostel Facilities Maintenance

HORM – Hybrid Optimal Replacement Model

HVAC – Heating a Ventilating and Air Conditioning System

ICYM – International College of Yayasan Malacca

IORM – Intelligent Optimal Replacement Model

KUIM – University College of Islam Malacca

MCDM – Multi Criteria Decision Making

MDT – Mean Downtime

MHIMS – Multiple Hybrid Intelligent Management Systems

MLE – Maximum- Likelihood Estimation

MTBF – Mean Time Between Failures

MTTF- Mean Time To Failure

MYR – Malaysia Ringgit

O – Occurrence

OF – Operate to Failure

OP – Operator Practice

ORM – Optimal Replacement Model

PM – Preventive Maintenance

RI – Random Index

RM – Replacement Maintenance

RPN – Risk Priority Number

S – Severity

SS – Subjective Survey

TPM – Total Productive Maintenance

UiTM – University of Technology Mara

US – Ultra Sonic

WOL – Wear-Out Life

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is presently in the intermediary phase of growth and industrialization where many building tasks are being prepared. The project of public building includes educational buildings, hospital buildings and government buildings (Hilde and Theo Van, 2011; Wilkinson and Reed, 2010). A number of building defects have arisen and been reported officially by the mass media, with several relating to educational buildings (Mydin et al., 2014). There are numerous defects which are common to hostel building components, such as roofs, walls, floors, ceilings, toilets, doors and windows. These defects may cause unexpected accidents and even death (Soleimanzadeh and Mydin, 2013). For example, on 12 September 2005, a teacher fell to his death when a decayed plywood floor of a two- storey school block in SJK (C) Keat Hwa, Kedah gave away. It is believed that the floor was ruined by termites (Isa et al., 2011). Based on the cases reported, defects can be concluded as fatally disparaging and critical because they bring impairment to their users and the building itself, causing damage, serious injury and death (Susan Aryee, 2011). Therefore, a study is important to investigate the contributing factors of those defects in order to create a safe buildings (Khozaei, 2011; Wahab and Hamid, 2011).Then a remediation plan can be developed based on the respective defects and failure to mitigate the impacts and also improve current conditions (Mydin et al., 2011). Users, investors, and public officials became more concerned after hearing about critical incidents involving the sudden collapse and failure of infrastructure components. Public awareness of these incidents and identification of potential failure areas have led to a perception of an infrastructure crisis (Naser et al., 2011). Table 1.1 provides failure issues, none of which are due to natural disasters, such as earthquakes or tornadoes, but are rather as a result of other causes, most probably lack of maintenance and repair, inadequate inspection and condition evaluation, insufficient funding, or more generally, inadequate management.

Table 1.1 Examples of Infrastructure Failures

Infrastructure Crisis	Bad Impact
4.12.2013 – Serdang Hospital ceiling collapse (www.utusan.com.my)	Four government employees were injured.
2.6.2009 – Sultan Mizan Zainal Abidin Stadium roof collapses (www.utusan.com.my)	Five construction workers were injured with three of them seriously hurt.
12.9.2005 – Teacher fell to his death from a decayed plywood floor of a two storey (Isa et al, 2011)	One death.
22.6.2015 – Mydin building collapse at Alor Gajah, Malacca: (www.thestar.com)	Three killed, six injured.
2001 – Highland Towers collapse was an apartment building collapse that occurred on 11 December 1993 in Taman Hillview, Ulu Klang, Selangor.	Up to 48 people were feared dead.
2002 – A school staircase collapsed in north China. (People's Daily 2005)	21 teenage students died and 47 more were injured.
India: Eleven killed in Mumbai building collapse (4.8.2015) http://www.bbc.com/news/world-asia-india-33769472	At least 11 people died after a building collapsed near India's western city of Mumbai.

However, more cases have happened recently and many were not reported in media officially.

According to Peng et al. (2013) and Olanrewaju et al. (2010), failure has been defined as the incapacity of a constructed facility or its components to perform as the building collapse occurs when the entire structure or substantial part of it comes down: the structure loses its ability to perform its function .

In building maintenance the component is usually subject to deterioration with usage and age. Building component deteriorations can increase the risk of component failure and deteriorate the product quality. In the past several decades, various preventive maintenance policies, models and optimisation approaches have been proposed. Some reviews and recent literature on preventive maintenance are listed as follows: (Nishith et al., 2015; Xia et al., 2012; Doostparast et al., 2014; Zhong et al., 2014; Ding et al., 2015).

Preventive maintenance (PM) activities generally consist of inspection, cleaning, lubrication, adjustment, alignment, and replacement of subcomponents that wear out. In general, PM activities can be categorised in one of two ways, component maintenance or component replacement. It is clear that PM involves a basic trade-off between the costs of conducting maintenance and replacement activities and the cost savings achieved by reducing the overall rate of occurrence of system failures. Designers of PM schedules must prioritise these individual costs to minimise the overall cost of system operation. They may also be interested in maximising the system reliability, subject to some sort of budget constraint.

Preventive replacement is one effective strategy to reduce the probability of failure (reduce failure cost) and downtime in the deterioration condition. Öhman et al. (2015) stated that preventive replacement is the most appropriate maintenance strategy for a component which operates in the stage of wear-out life (WOL). However, the best time to carry out the preventive replacement must be considered. If preventive replacement is applied too frequently, the cost of maintenance and system downtime will increase. If preventive replacement is only applied occasionally, it will increase the downtime of sudden failures (breakdowns) plus downtime for maintenance.

Hence, compromise between these two replacement conditions (too frequently and too occasionally) will result in the optimum time of replacement, which minimises the total system cost of downtime due to maintenance downtime and sudden failure downtime. An optimisation model is a mathematical model that refers to choosing the best solution from all feasible solutions. Optimisation models have been widely developed and used to find optimal PM and a replacement for a variety of systems.

Before the optimisation model is developed, it is essential to identify the maintenance problem. Several models are identified: for example, snapshot (Basari, 2009), FMECA (Hasbullah and Ahmad, 2015) and DTA (Jones et al., 2009). The purpose of maintenance problem identification is to find the cause of failure or fault, type of failure, effect due to the failure and prevention action. The output of the maintenance problem identification is the most critical components. These components will be used as a critical part to be modelled in order to find the optimal maintenance solution.

The establishment of artificial intelligence (AI) has the advantage of being useful in optimizing complex problems. There is enormous potential for developments in many applications of AI in maintenance by combining or hybridizing two or more AI techniques to select an appropriate model for analysis.

1.2 Problem Statement

Most hostel facilities maintenance have a maintenance model, such as maintenance schedule, maintenance plan, maintenance training and so on. This model assists in various facilities and areas in identifying problems in the university hostel such as component damage, cost, downtime, maintenance frequency, skill, and knowledge (Oladiran and Yaba, 2013). However, there is very little continuous maintenance management conducted to analyse the criticality of the hostel facilities. In addition, there is a lack of a specific model to look at cost effectiveness for the hostel facilities maintenance (HFM). Based on the stated issues, the identified problems of HFM are:

1. The most critical component in hostel facilities maintenance in Higher Education Institutions (HEI's) is still a lack of accuracy and misleading. According to Lind et al., 2012, maintenance problem identification based on the snapshot model in the case of failure data is essential for maintenance engineers to analyse the maintenance problems. In the current snapshot model, there is an analysis of the major fault type where each component is listed with the number of faults. For instance, if a component that develops the highest number of faults is identified, it will disrupt the maintenance work of the hostel facilities and this will incur cost and downtime. Thus, ranking such a component as the most critical one is misleading. Even though the ranking is established and proper analyses are conducted, an overall ranking based on all the criteria is not considered. This could have no meaning to the users (maintenance staff) and lead to wrong decisions (Burhanuddin et al., 2015). Deeper analysis also needs to be considered to increase the accuracy of maintenance problem identification which could affect the whole building component (Swallow, 2007).

2. The hostel facilities maintenance lacks a modelling method to identify the frequency of maintenance in a given period of time. The most important point of this problem is