Post-mortem Interval Estimation System (e-PMI) in Estimating the Time of Death

Zuriana Abu Bakar, Muhammad Bin Che Abdullah, and Noor Maizura Mohd Noor

***Abstract*—Technology has a great impact on human civilization. In order to bring the technology to meet its requirement, a system is developed. A system is a collection of elements or components that are organized for a common purpose. Through a system, technology is able to meet its requirements and benefit humans. In terms of crime investigation, previously, most of the crime investigation processes had been done manually. However, Asante (2013) had developed a simple application, which concerns the time of death estimation. However, this application was not a fully automatic system and was unable to give a proper contribution to the forensic science field and the time of death estimation. Thus, the Post-Mortem Interval Estimation System (e-PMI) was developed to assist in estimating the time of death by considering rectum temperature, ambient temperature, weight of corpse, layer of corpse's clothes, condition of corpse, and the condition of air and water. This system is expected to become the base system in estimating the time of death in order to produce a more reliable and better result.**

***Index Terms*—Technology, system, time of death.**

I. Introduction

Technology refers to the core knowledge dedicated to create tools, unfolding the actions, and drawing out materials. In fact, technology can be described as products, processes, or even organizations. It is purposely designed to extend human abilities, which is the most significant part in any technological system. Thus, human abilities can accomplish even greater achievements, which then raise the credibility of humans. Technology also represents an application of science in solving problems. It assists in solving problems in communication, transportation, learning, manufacturing, creating artifacts, securing data, scaling businesses, and so on. A well-applied technology could benefit humans and create a new economic environment. The advancement of technology raises the information age which provides different work environment for highly competitive demands especially in business and in accomplishing various tasks [1].

According to Ackerley [2], a system is a collection of elements or components that are organized for a common purpose. A system is a type of technology, which is developed to assist in human life. With an efficient system, many works that have been done manually can now be done automatically with less time consumed. Thus, a system imparts an outstanding benefit towards humans. Science is also related to crime observation. The field is known as forensic science. Forensic science is any science used for the purpose of law, which also provides impartial scientific evidence for use in the courts of law such as in criminal investigation and trial [3]. Forensic science is also an application of broad spectrum of science and technology that helps in investigations or in establishing facts of interest in relation to crime investigation or civil law [4]. In other words, forensic science is a legal way of investigating a crime scene as the source of information or evidence resources for any crime that occurs. For any cases that happen, forensic science is a bridge that connects the investigator to the attribute or things to find the source of the problem. It leads the investigators to find the clue, the proof, the suspect, the alibi, time of murder, and so on. The role of forensic science in the criminal justice arena is changing drastically. In the past, forensic science analysis often entered into the picture near the end of the criminal investigative process, which is after the crime, after the investigation, after the arrest of a suspect, but before prosecution [5]. Currently, the forensic work often precedes an arrest. The changes in the role of forensic science has substantially increased the significance of the forensic science in the criminal investigative process. This is mainly due to two factors: the increased awareness of forensic science and the advances in technology [6].

An algorithm had been proposed by Asante for time of death estimation in the forensic field [7]. The algorithm had been tested through a prototype application to examine the algorithm for estimating the time of death. However, the simple application had not been developed into an automatic system, which could provide a proper contribution towards the forensic science field. Therefore, throughout this paper, an automated system prototype for estimating the time of death will be discussed clearly namely the Post-Mortem Interval Estimation System (e-PMI).

The remainder of this paper is organized as follows. Section II discusses the e-PMI System while Section III explains the architecture of the system. The expected result for this study is discussed in Section IV and finally, the conclusion is presented in Section V.

II. Post-mortem Interval Estimation System (e-PMI)

Previously, Asante (2013) had developed an application to estimate the time death based on the Newton Law of Cooling method [7]. The Newton Law of Cooling system had been developed using an algorithm and is being tested as an application. The algorithm is developed based on a first-order linear differential equation formulated by Newton and

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The authors are with the Computer Science Department in Universiti Malaysia Terengganu, Malaysia (e-mail: zuriana@umt.edu.my, gsk1749@pps.umt.edu.my, maizura@umt.edu.my).

modified with a two-exponential-model by Marshall and Hoare (1962) [7]. These methods are often used for calculating the heat transfer by convection [8]. Besides, it is also claimed that the rate in which a warm body cools is approximately proportional to the difference between the temperatures of a warm object with a temperature of its environment [7].

However, researchers have found that Asante's (2013) application did not take into account the other variables that could improve the accuracy of the death estimation such as the variables in Henssge nomogram's corrective factors, posture of the body, site of reading of the postmortem body temperature, emaciation and microenvironment such as rain or humidity and others.

Asante's (2013) application only concerns the rectum temperature, ambient temperature, mass or weight of corpse and the condition of the corpse's body (e.g. clothed or naked) [7]. Thus, this study aims to enhance the application developed by Asante (2013) by adding more variables in the application, namely the e-PMI system, in order to grant more accurate and better results in estimating the time of death.

The algorithm proposed by Abdullah etc. [9] had been taken into account in developing the e-PMI system. The system is developed based on the following formula, which had then been simplified and modified by Asante (2013).

$$\frac{dT}{dt} = -k\,(T\text{-}T_a) \qquad (1)$$

where

T = Temperature of cooling object at time t
t = time in hours since the first reading
T_a = Temperature of surrounding medium
k = constant proportionality

Then, the formula is differentiated and integrated mathematically before being developed into a system as follows:

$$\text{At } t = 0,\ T(0) = T_0 \qquad (2)$$

Afterward, the formula is reduced to the final solution as,

$$T(t) = T_a + (T_0 - T_a)e^{-kt} + \frac{k}{k-p}(T_0 - T_a)(e^{-pt} - e^{-kt}) \qquad (3)$$

where

k = rate constant known as cooling factor
t = time in hours since the first reading
T = rectal temperature at any time
T_a = ambient temperature
T_o = rectal temperature at death (t = 0)
p = rate constant for the Plateau

Finally, all the criteria from Asante's application had been included and it has been enhanced with the additional factors from Henssge nomogram's corrective factor to increase the efficiency of the system.

III. Architecture for e-PMI System

E-PMI is developed to estimate the time of death based on certain factors. Fig. 1 illustrates the architecture of the e-PMI System. From Fig. 1, it can be seen that the input of e-PMI system is the criteria (variables) that is obtained from the crime scene, where time of cadaver or corpse found, rectum temperature, room temperature, mass of cadaver or corpse, condition of corpse or cadaver body, condition of clothes of the corpse or cadaver, layer of the clothes, condition of air and condition of water. Next, all of the criteria that had been input will be incorporated into Graphical User Interface (GUI) System of e-PMI System. Then, the data that was inserted into the algorithm will be analyzed to predict the time of death. Finally, the estimation of time of death will be stored in the database and will be produced as the reports.

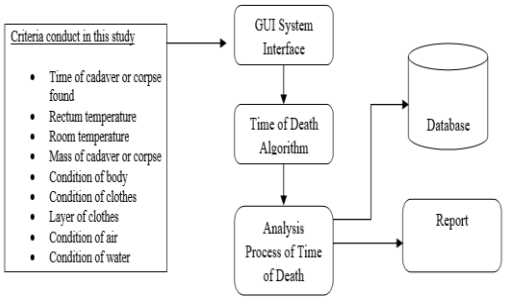

Fig. 1. The e-PMI system for estimating the time of death.

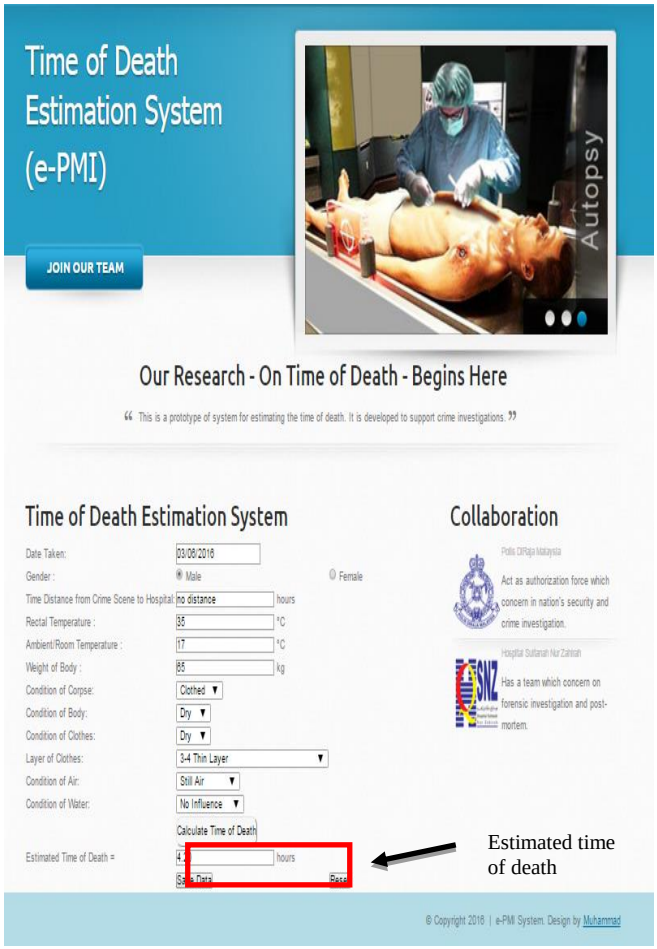

Fig. 2. The input interface of the e-PMI system.

Fig. 2 shows the interface to input the data into the e-PMI System. The users are required to provide the information needed for estimating the time of death by entering all required information into the input boxes. Then, from that information, the estimation time of death could be calculated

(as marked with the red box in Fig. 2). Next, the information provided and the estimated time of death could be saved and viewed as shown in Fig. 3.

TABLE I: RESULT FROM ASANTE APPLICATION

Case	Age	Sex	Known time of death (hours)	Rectal temperature (℃)	Ambient temperature (℃)	Body weight (kg)	Clothed (+) Naked (-)	Estimate time (hours)
1	51	M	4	34.9	17	168	+	3.94
2	54	F	4	34.4	22	160	+	5.44
3	54	M	4	35.1	19.3	180	+	4.29
4	26	F	4	34.7	22.5	166	-	4.85
5	16	M	4	35.9	22.4	175	-	2.96

TABLE II: RESULT FROM E-PMI SYSTEM COMPARED TO THE KNOWN TIME OF DEATH

Case	Age	Sex	Known time of death (hours)	Rectal Temp (℃)	Ambient Temp (℃)	Body Weight (kg)	Clothed (+) Naked (-)	Asante estimate time (hours)	Layer of Cloth	Condition of Air	Condition of Water	e-PMI System estimate time (hours)
1	51	M	4	34.9	17	65	+	3.94	1-2 Thin	Moving Air	No Influence	3.80
1	51	M	4	34.9	17	65	+	3.94	2-3 Thin	Moving Air	No Influence	4.20
1	51	M	4	34.9	17	65	+	3.94	3-4 Thin	Moving Air	No Influence	4.32
1	51	M	4	34.9	17	65	+	3.94	1-2 Thick	Moving Air	No Influence	4.20
1	51	M	4	34.9	17	65	+	3.94	2 or more Thicker	Moving Air	No Influence	3.51
1	51	M	4	34.9	17	65	+	3.94	Thick Bedspread	Moving Air	No Influence	4.93
2	54	F	4	34.4	22	65	+	5.44	1-2 Thin	Moving Air	No Influence	5.24
2	54	F	4	34.4	22	65	+	5.44	2-3 Thin	Moving Air	No Influence	5.81
2	54	F	4	34.4	22	65	+	5.44	3-4 Thin	Moving Air	No Influence	6.00
3	54	M	4	35.1	19.3	78	+	4.29	1-2 Thin	Moving Air	No Influence	4.12
3	54	M	4	35.1	19.3	78	+	4.29	2-3 Thin	Moving Air	No Influence	4.59
3	54	M	4	35.1	19.3	78	+	4.29	3-4 Thin	Moving Air	No Influence	4.74
4	26	F	4	34.7	22.5	75	-	4.85	Naked	Moving / Still Air	No Influence	4.35
4	26	F	4	34.7	22.5	75	-	4.85	Naked	No Influence	Flowing Water	3.42
4	26	F	4	34.7	22.5	75	-	4.85	Naked	No Influence	Still Water	3.81
5	16	M	4	35.9	22.4	65	-	2.96	Naked	Moving / Still Air	No Influence	2.68
5	16	M	4	35.9	22.4	65	-	2.96	Naked	No Influence	Flowing Water	2.15
5	16	M	4	35.9	22.4	65	-	2.96	Naked	No Influence	Still Water	2.37

Finally, all the data that had been saved could be printed out as reports, as shown in Fig. 4. The reports could be printed in two ways, which are monthly or yearly cases. By this auto-generated report, crime investigation process could be done effectively in a short time as the report can be obtained directly right after the investigation process had been done.

IV. THE RESULT

Asante's (2013) application had produced some results regarding the time of death analysis. It takes ambient temperature, weight of the body, rectal temperature, and initial temperature into consideration in estimating the time of death. The results of the application developed by Asante (2013) are shown in Table I. The results show that the estimated time could be considered effective as most of the estimated time is approximately with the "known time of death". However, Cases 2 and 5 had outliers in the result due to the longer postmortem period.

A pilot study had been carried out in order to test the effectiveness of the e-PMI System. The results of the pilot study are shown in Table II. The e-PMI System estimation time could be considered effective if the estimated time is equal or approximately the time of the "known time of death". As can be seen from Table II, e-PMI System results meet the known time of death as the results are not too far from the known time of death. Therefore, this proves that the corrective factors used in this e-PMI system in which those factors were from Henssge nomogram and incorporated with

Asante's (2013) algorithm could have a great influence on the estimated time of death. However, there are certain results (for example Cases 2 and 5) with an outlier from the known time of death. This is due to the longer process of the postmortem interval in which the e-PMI system could only cater to the shorter postmortem interval.

Fig. 3. The cases viewed by the system screen.

Fig. 4. Sample of e-PMI system report.

V. Conclusion

As a conclusion, estimating the time of death greatly facilitates the crime investigation. Thus, this substantiation demonstrates that the system can be applied and contributed in crime investigation. Based on Tables I and II, it can be concluded that the e-PMI meets the known time of death. It could indicate a positive result towards estimating the time of death as the result still moves around the known time of death. While the attention is still on the time of death, time of death is described as the time elapse since a person died. The longer the post mortem interval, the time of death estimation becomes less accurate and unreliable.

In addition, by reducing the post mortem interval, the time of death estimation could become more accurate and reliable. Therefore, a reliable result from the time of death estimation will become a significant thing, so that, it will connect with the crime cases. To produce a reliable result, all the data that has been gathered from the corpses must be included. Therefore, the e-PMI System is expected to become the base system in estimating the time of death in order to produce a more reliable and better result. A system, which considers more attributes, or variables from any areas in forensic science field is urged to contribute in making the time of death estimation become more accurate and reliable.

For future work, the system should cater for a long postmortem interval process. This could increase the efficiency and effectiveness of the current system in estimating the time of death. Besides, it could also increase the reliability and accuracy of the system in estimating the time of death.

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Zuriana Abu Bakar is currently lecturer in Computer Science Department, University Malaysia Terengganu. She received her PhD from Queensland University. Her area of expertise is in human computer interaction and her research interest is in interaction design, affective computing, and forensic computing.

Muhammad Bin Che Abdullah is currently a master degree student in the Computer Science Department, University Malaysia Terengganu. He received a degree in computer science major in software engineering from University Malaysia Terengganu in 2012. His research interest is in network application and decision support system.

Noor Maizura Mohamad Noor is currently a deputy director of Quality Centre and Academic Development (PKPA) Universiti Malaysia Terengganu (UMT). She received her PhD degree from the Manchester University, UK in 2005. Her recent research work focuses on improving organizational decision making practices through the use of technologies. This includes research interests in the design, development, and evaluation of decision support systems for analyzing and improving decision processes. Her research interests also focus on the areas of computer science, intelligent decision support system, clinical decision support system, and information system. She is an editor of books, conferences proceedings, and a reviewer and editorial board of International Journals. Her contribution to scientific computing has been recognized by receiving several awards including the Best Scientist Award (2009), Product and Research Innovation Award for International and National Level (2008 and 2009) of UMT. She is a member of ACM and IACSIT.