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Research Article

A Procedural Algorithm for Biomedical E-Waste Management

Abel Kamagara[1]*, Bridget Atukunda[2], Mercy Kekirunga[2]

[1]Faculty of Engineering, Department of Electrical and Electronics Engineering, Kyambogo University, P.O.Box 1 Kyambogo, Kampala, Uganda; [2]Faculty of Applied Sciences and Technology, Department of Electrical and Electronics Engineering, Mbarara University of Science and Technology, P.O.Box 1410 Mbarara, Mbarara City, Uganda

ABSTRACT

In this paper, a procedural algorithm for biomedical electronic obsolescence and subsequently, an online E-waste management system is presented. To accomplish this, the following was done; (i) Analyzed several standard procedures followed to declare biomedical equipment obsolete, and (ii) generated an online database that procedurally compares and categorizes degrees of obsolescence for different biomedical equipment. Results show that our algorithm is able to procedurally predict whether the equipment is obsolete or functional and further produce a tabular representation of the same for further reference and action. This is promising for better electronic and/or inventory management in the hospital and can seemingly foster environmental preservation through reduced electronic waste pollution.

Keywords: Biomedical Instrumentation; Procedural Algorithm; E-Waste Management

INTRODUCTION

The word obsolescence is derived from a Latin term obsolescere that means to get old fashioned or get worn out [1]. Therefore, obsolescence can be defined as the process of getting outdated and no longer being in use. Obsolescence may be categorized into different types as follows [2-6];

1. Logistical obsolescence. This is brought about by the inability to secure components, materials or software needed to manufacture or maintain a product.

2. Functional obsolescence. In this type of obsolescence, equipment becomes obsolete because of an outdated design feature that it cannot easily be updated.

3. Technological obsolescence. This occurs when a product or service is no longer needed mainly because a new version of it has been created to replace it. This product may still be in its proper working order or it may breakdown but its cost of repair and maintenance is very high [1].

4. Planned obsolescence: Planned obsolescence can be defined as a condition when a device is built by the manufacturer in order for it to last only a few years so that the user can obtain

another.

In the recent decades, due to technological advancements in production methods and techniques, usually, the manufacturers of medical and biomedical devices seemingly design equipment in such a way that makes it very difficult and expensive to repair once gone faulty or unfunctional. This is increasingly likely in developing economies like Uganda. To remain operational, clients especially hospitals opt to buy a new equipment rather than diagnosing the faulty or unfunctional devices. In some instances, in an endeavors to increase sales, some manufacturers have been discovered to intentionally insert certain defective components to shorten the lifespan of the equipment or put the equipment in a wrong place so that it easily gets damaged. Moreover, manufacturers do planned obsolescence because of the fact that people need to keep buying things (stay up to date with the changing technology). This benefits the manufacturer since his/her main aim is to maximize sales and yet this financially stresses the clients because of the high cost of purchase of this equipment. There are a number of factors which drive obsolescence and they include [2].

• Market change; all markets change, demand alters for many different reasons, with electronics being the backbone of these consumer products, the demand for components has to change since markets keep changing.

• Technological evolution; a new and mostly further developed generation of technology will inevitably replace older technologies impacting on availability. Technologies with a high rate of innovation will inevitably suffer higher rates of component obsolescence.

***Corresponding to**: Abel Kamagara, Faculty of Engineering, Department of Electrical and Electronics Engineering, Kyambogo University, P.O.Box 1 Kyambogo, Kampala, Uganda, E-mail: kmgra@hotmail.com

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• Technology revolution; in an increasing number of cases, old technology is being completely replaced by new technology [2]. In some cases in the biomedical industry where clinical trials can sometimes last beyond 18 months, some products become obsolete even before production is complete yet technology continues to advance.

Biomedical devices are instruments that are used to enable safe and effective prevention or treatment of diseases for example X-ray machines, Position Emission Tomography and Computed Tomography scanners, MRI machines. Biomedical devices can be categorized into imaging devices cardiovascular devices, surgical devices, skin devices and lastly tissue devices [7-12]. The Biomedical industry is slow to change since new medical devices are very costly and have long development times and upgrades are not easy. Because they rely on a supply chain that was originally and primarily developed for rapidly changing industries such as consumer electronics, this has resulted into unplanned medical electronic obsolescence. Some of the examples of discontinued medical products due to obsolescence include ABPM6100 blood pressure monitor, AED 10 defibrillator, CL100 SFI Surgical Headlight System [3,13,14].

To circumvent all aforementioned limitations between manufacturers and clientele (mostly hospitals) of biomedical equipment and devices, the cardinal goal of our research project was to design and implement a procedural algorithm for biomedical electronic obsolescence and if possible incorporate and /or modify it into an electronic waste management system.

APPROACH AND METHODOLOGY

Procedural algorithm followed in developing a database is described and depicted in Figure 1.

- Step 1: Capture parameter specifications into the database.
- Step 2: Capture new values of the parameters from the failed biomedical equipment.
- Step 3: Compare the new values of the parameters with the initial values captured into the database.
- Step 4: If the new value of the parameter is not within the range, establish the cause of failure, find out if the cause can be rectified. If the cause can be rectified, repair and if the cause cannot be rectified, declare obsolescence.
- Step 5: Stop.

Software tools used include; MySQL database, Hyper Text Markup Language, Sublime text, PHP scripting language, and WAMP server. The Procedure of the approach is given herein as follows;

(1)The database was created using MySQL workbench, (2) Forms to interact with the database were created using HTML and CSS languages for example login form, register device form, and

(3) The PHP codes to interact with the database were written.

RESULTS

In Figure 2, for a user to access the system, login credentials are required. If the user name and password are correct, the user can access the system and if they are incorrect the system takes the user back to the login menu.

The system has a user login interface which requires the user to enter his or her credentials as shown in Figure 3. This part of the system is for protection against unauthorized personnel.

Once the users' credentials have been verified, they can access the system user interface which enables them to access reports, view the equipment in the system and check the status of the faulty equipment which can either be declared obsolete or still be functional. This system predicts biomedical electronic

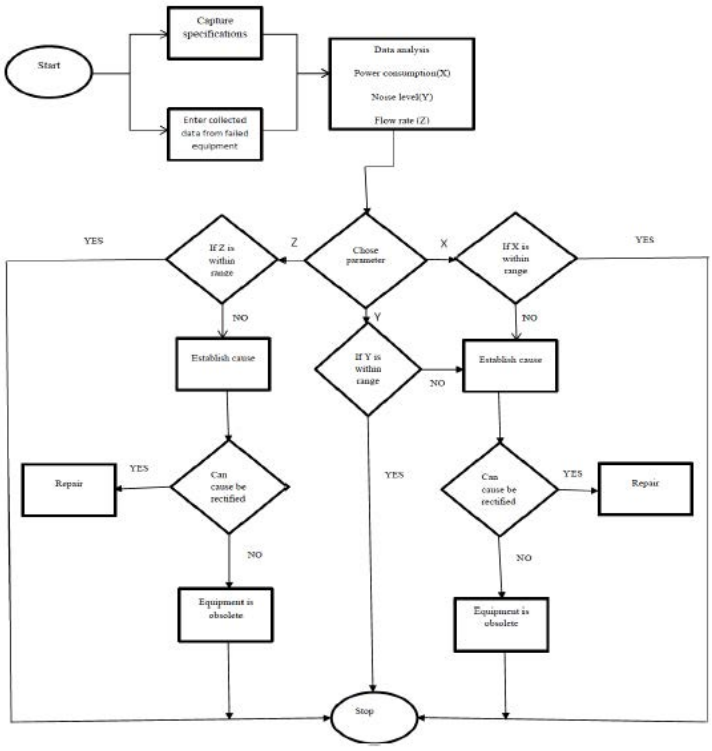

Figure 1: Procedural algorithm flow chart.

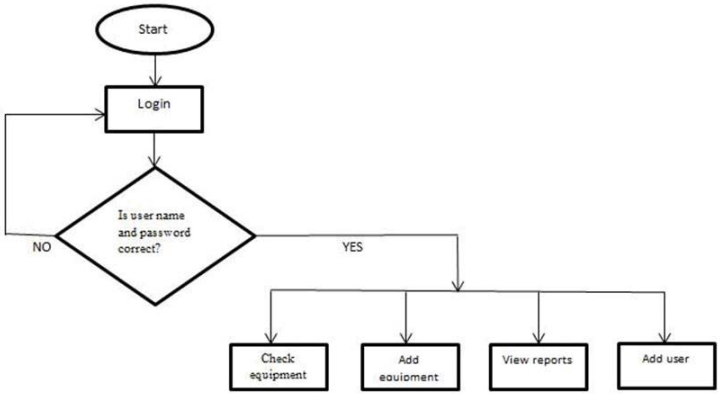

Figure 2: User system flow chart.

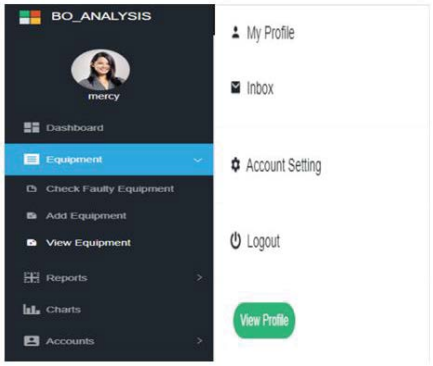

Figure 3: User Interface.

REPORT OF CHECKED DEVICES

CheckList Id	Date Checked	Device Checked	Device Status	Checked By
3	2021-09-09	Suction pump	Obsolete	mercy
4	2021-09-09	Suction pump	Works Well	mercy
5	2021-09-09	Oxygen Concentrator	Obsolete	mercy
6	2021-09-09	Xray Machine	Works Well	mercy
7	2021-09-09	Xray Machine	Works Well	mercy
9	2021-09-09	Infusion pump	Obsolete	mercy
10	2021-09-10	Suction pump	Works Well	mercy
11	2021-09-10	Infusion pump	Obsolete	mercy
12	2021-09-10	Infusion pump	Obsolete	mercy

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Figure 4: Report list of biomedical equipment and devices.

obsolescence. It indicates the status of the equipment that has been checked, generates reports of the equipment that has been checked, their status and who checked them as shown in Figure 4. This is to reduce on double checking the equipment. The system also keeps data for future reference and also allows the user to add equipment that is not within the system.

CONCLUSION

In conclusion, a system that procedurally predicts biomedical electronic obsolescence is presented. This system uses a procedural algorithm where by the values of the technical specifications of the equipment are captured into a database; new values of the same specifications from the same failed equipment are also captured into the database. The data is compared and the status of the equipment is outputted. This algorithm is able to procedurally predict whether equipment is obsolete or functional. Therefore, this procedural algorithm once implemented by MRRH will help improve inventory management and electronic waste management. This algorithm can also be implemented by other sectors that are affected by obsolescence.

Our recommendation is that an electronic waste management system (EWMS) should be put into consideration and also implemented by MRRH because once a biomedical equipment is declared obsolete, it implies that an equipment is no longer functional hence the need for disposal.

This calls for a proper EWMS which will ensure proper disposal of

electronic waste. Future work is to work on a Biomedical EWMS within which our algorithm can be incorporated. This system will therefore be able to categorize and predict biomedical equipment obsolescence plus ensure proper electronic waste management.

DECLARATION

The authors declare that there is absolutely no conflict of interest involved in production of this manuscript.

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