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AUTO-SORTING WASTE DETECTION SYSTEM FOR SERVICE-ORIENTED WELL-BEING SOLUTION

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ABSTRACT

Service-based value creation for well-being solution is an urgent requirement in business and social sustainability. Proper management of waste can help to ensure service-oriented value; thereby business and society can enjoy sustainability. From the macro perspective, it can be observed that waste is a phenomenal volume of mixed complex materials that can become useless output if one does not put into place a step of circular solution, which is recycle, reuse, and reduce (3R). However, before any of the 3R can be a success, waste must be sorted by separating them into organic vs. inorganic, and recyclable vs. unrecyclable to make the process of 3R more effective. Usually, most people are less aware or do not have enough knowledge regarding storage of their waste. This study proposes an effective and a prominent system to sort out and detect trash in an auto-waste sorting detection machine. The qualitative method will be conducted for data collection through semi-structured interviews with experts of solid waste management. This research can potentially help to improve the realization of the mandatory source separation required by the Malaysian government and the implementation of Act 672 about waste separation at source and recycling in Malaysia.

Key words: *Solid Waste Management, Separating Waste, Sorting Waste, Automatic, Detection, Well-Being*

INTRODUCTION

Environmental issues and effective waste management continue to present greater challenges day by day around the globe. Waste is considered as garbage, refuse, or other discarded materials, including solid, liquid, semi-solid, or contained gaseous material that come from domestic, community, industrial, commercial, institution, agricultural, or human operations (Jayarama, 2011). Other things that are also considered as waste include the sludge from treatment plants as well as the air pollution control facility.

It was explained by Szaky (2014) that over 100 years, the amount of waste that a single person produces has risen by almost 10,000%. It happens due to the lack of knowledge in waste management, as well as technological limitations of waste management systems. The lack of waste management knowledge or system is heavily seen in developing countries, especially in generating and composing the waste. Unlike developed countries, where per capita income is high like the cities in Japan, the average rate of waste generation can be as high as 1.64 kg per capita per day,

whereas in the cities where the per capita income is in the middle range like in Thailand or Malaysia, the average rate of waste generation is about 0.74 kg per capita per day (Jayarama, 2011). Environmental issues associated with solid waste problems continue to become a serious problem in Malaysia (Hassan, Chong, & Rahman, 2005).

In this era of modern lifestyle, lack of public conscience has resulted in the increase of amount of waste generated and waste disposed in the landfills. Dealing with waste issues is a global challenge, including in Malaysia, with the annual increase in solid waste generation rely heavily on landfills which bear the issues of space limitations, public health, and environmental issues. Therefore, increase in recycling at the household level might reduce this persistent problem of increasing solid waste generation (Moh & Manaf, 2016). However, one of the most critical challenges in source separation and recycling practice is public attitude toward actually doing source separation and recycling to become a habit of the public. There is lack of awareness among people and technological systems to separate waste into organic, inorganic, recyclable, and unrecyclable waste.

Therefore, in this research, a potential solution is proposed in the form of an auto-sorting waste detection service system named “modern trash detection machine”. This system will help to identify solid waste (example, glass, can, paper, food, and etc.) easily and contribute toward a healthier society and lead to improve the quality of sorting waste management efficiently and effectively. It can also help practical solid waste management companies in separating many kinds of municipal solid waste that will be recycled, and thus can assist in performing the economic role for the nation. The rest of the paper is organised as follows. Section 2 reviews the literature on waste management, including current practices of waste management in Malaysia, while Section 3 analyses the data. Next, Section 4 describes the auto-sorting waste detection system. Meanwhile, Section 5 refers to the implementation of an auto-sorting waste detection system, and the final section concludes the paper with a summary.

PREVIOUS RESEARCH REVIEW ON WASTE MANAGEMENT

Malaysia has increased their generation of municipal solid waste (MSW) to more than 91%. It has become the biggest environmental problem in Malaysia (Samsudin & Don, 2013). In Kuala Lumpur the capital city of Malaysia, there is uncontrolled consumption due to increase in the population that has accelerated waste generation considerably. Moreover, solid waste generation has increased at an uncontrollable rate due to the dispensable utilisation of plastic and paper material used for packaging (Jalil, 2010).

This problem occurs in Malaysia because of lack of public awareness, environmental education, and technical skill regarding the importance of community involvement in recycling programmes (Samsudin & Don, 2013). This was evident in a previous campaign with the motto of “Kembalikan Sinar kepada Pulau Mutiara” (translated as “restoring the shine to the Pearl of the Orient”), whereby this motto was created exactly for Penang’s residents in order to raise their awareness of recycling waste, but it was not successful in making the motto come true. About 40-60% of waste that could not be recycled was found in recycle bins (Meen-Chee & Narayanan, 2006).

That is a proof that Malaysian people are still lacking in awareness of recycling of waste.

CURRENT PRACTICE OF WASTE MANAGEMENT IN MALAYSIA

At present, there is another problem as well that causes the increase of the waste generation rate in Malaysia, which is that their current solid waste management is still employing landfills and most sites are open dumping areas (Samsudin & Don, 2013). Additionally, in 2001, incineration is not new technology in Malaysia to dispose hazardous waste, since it was implemented in some islands in Malaysia, such as Langkawi, Patong, Tioman, and Labuan, but now these ongoing projects have already been terminated because of the issue of pollution surrounding the incineration area—it being a burden to the environment (Manaf, Samah, & Zukki, 2009). Table 1 shows the percentage of waste treatment methods applied in Malaysia.

Table 1
Waste treatment method practice in Malaysia (Samsudin & Don, 2013).

Treatment Methods	Percentage (%)		
	2002	2006	Target 2020
Recycling	5.0	5.5	22.0
Composting	0.0	0.0	8.0
Incinerating	0.0	0.0	16.8
Inert landfill	0.0	3.2	9.1
Sanitary landfill	5.0	30.9	44.1
Other disposal sites	90.0	59.4	0.0
Total	100.0	100.0	100.0

In order to achieve genuine progress toward sustainability, Malaysia need to focus their future prospects and potentials of municipal solid waste management in Malaysia. There are seven targets that can be a driver for municipal solid waste management improvement: (i) improve public behaviour, awareness, and education, (ii) waste prevention and minimization, (iii) waste recycling and composting, (iv) energy recovery from municipal solid waste, (v) improve landfill systems, (vi) greater role of non-government, and (vii) integrated approach (Samsudin & Don, 2013).

In 1991, Malaysia set a goal to become a developed nation by 2020 (Vision 2020, <http://www.wawasan2020.com/vision/index.html>) and also signed a commitment to the principle of sustainable development in the Rio Declaration. The government of Malaysia is committed to improving their solid waste management to achieve their Vision 2020 (Moh & Manaf, 2016). So, the National Strategic Plan (NSP) for solid waste management becomes the planned guideline that consolidates economic development and all stakeholders' needs to set up the improvement of a solid waste management system (Moh & Manaf, 2016).

One of the NSP frameworks is Waste Minimisation Master Plan (WM-MP), which is committed to introduce ways to minimise consumption of natural resource and minimise the reduction of environmental load. WM-MP targets the government level, private sector level and public level as their stakeholders that form the basis of WM-

MP, which are (i) enhancement of awareness on waste minimization, (ii) strengthening of partnership for 3Rs activities, and (iii) enhancement of institutions to strengthen government policies on waste minimisation (Moh & Manaf, 2016).

By implementing those frameworks, Malaysia formulated the Solid Waste and Public Cleansing Management Act 2007 (Act 672 and Act 673). Act 672 is to standardise solid waste management and public cleansing service in Malaysia that ensures the proper municipal solid waste, particularly household waste management, with a promotion of waste separation at source and recycling throughout Peninsular Malaysia. Therefore, the issue is to innovate and make significant improvements by using advanced technology to achieve the goal of Act 672, which is to ensure an efficient and proper waste management system by increasing the number of people performing waste separation at the source in order to make recycling more effective and efficient.

DATA COLLECTION AND ANALYSIS

Data Collection Process

Primary data were collected through interviews with experts of solid waste management in process separation and process recycling. Secondary data were also gathered and analysed as well. Regarding the interview method, the aim of interview sessions was to get more useful information and perspectives from experts of solid waste management and their valuable experiences in conducting the recycling process. The purpose of this interview was also to achieve the objectives of study that can assist solid waste management companies in separating many kinds of municipal solid waste that will be recycled and thus improve the quality of sorting waste management, effectively as well as efficiently.

Interviews began with the identification of the expertise to get their background and their main source information of engaging in the solid waste management company. The experts also addressed the presented questions during the interview in relation to their knowledge and perspective about the process of waste separation. After that, the main topic was addressed and the researcher asked their opinions about the installation of the modern trash detection machine under study. The structure of interview questions is given bellow.

Table 1
Interview questions structure.

Waste Separation Aspect
a. What do you know about waste separating process?
b. Is waste separating process continuous before the waste is dumped into landfills?
c. Is there any certain processes that take place in separating this waste? Such as using some machine or is it done manually?
d. Is there any waste that you get from households that has been separated? Approximately is that in the big amount or just a little?
e. What do you think about people awareness of separating their waste at the source?

Modern trash detection machine aspect

- a What do you think about this modern trash detection machine?
- b What do you think about the challenge if this machine is going to be installed in many places especially in the household?
- c What do you think about the positive and negative impact of this machine from the social aspect, economic aspect, and human life quality?

Meanwhile, secondary data were collected from online sources, journals, and articles. Gaining more knowledge and information based on the scope of this research can be applied to help the analysis of the research, since the literature review can be more effective and gives views from many angles. More information can be garnered for this study through secondary data, such as from a journal called “Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia”, which was revised on 22 April 2016, and many other journals. This study also employed information from books, which are needed to gain more knowledge about solid waste management. In addition, this study also used data from newspapers as well.

ANALYSIS OF DATA

The interviews were conducted with a number of respondents to share their knowledge and their experience. In collecting the data, the researcher ensured that all of the respondents are experts in the solid waste management aspect and their ages were between 28 to 59 years. The authors also carefully chose respondents from both academia (scholars) and the industry (practitioners), such as two respondents from Green Resource Recovery Sendirian Berhad, which is a private company that is in the waste management and recycling business. This study identified that in general, this company provides the facilities for recycling and waste management service, such as collecting waste in certain areas (especially in Kedah and Perlis area), separating waste into plastic, paper, and metal or tin, and shipping waste that has been separated to another company to be recycled. In addition, respondents were also selected from Universiti Utara Malaysia, who are experts in solid waste management.

Waste Separation Aspect

All respondents have almost similar opinions about separation of waste. They are also aware that the government of Malaysia has implemented with the mandatory separating of waste since September 2015, where waste is separated according to four categories, which are food waste and domestic waste (to be put into the green container that company provides in each house), and recyclable waste such as plastic, paper, as well as metal or tin materials. People need to separate the recyclable waste in separate plastic bags and just put them beside the green container that the company has provided to them. Then, the company will collect the domestic waste two times per week at each house and the waste is directly transported and dumped into a landfill. The company also collects recycled waste once a week; they call it the “2+1 formulation” (meaning two days of collecting domestic waste and one day to collect recycled waste in a week). Then, in certain public areas, they also provide a 3R cage

where the public can store the waste that has been separated by them in that 3R cage, as shown in Figure 1.

Until now, the separation process of waste that people perform in the household is manually, but the waste separation process in the recovery company is done by using a semi-automatic process. In the recovery company they use a conveyor machine, but still need employees to separate the waste into plastic, paper, and tin containers. Using the semi-automatic system, they also divide plastic and paper into some further categories. Plastics can be divided into PET, HDPE, LDPE, PVC, and mixed plastic. Papers are divided into A4, black and white paper, newspaper, and mixed paper.

Figure 1

3R Cage. Retrieve from Green Resource Recovery Facebook page
(<https://www.facebook.com/Green-Resource-Recovery-Sdn-Bhd-731782796933932/>)



After a year since the implementation of the mandatory waste separation in Malaysia, the latest data from Solid Waste Corporation (SWCorp) showed that the amount of 1.56 million tons of waste was dumped between January 2016 and June 2016, as compared to the amount of 1.79 million tons during the same period in 2015 (Zulkipli & Dawum, 2016). Here, a decrease of waste that is dumped into the landfill can be observed to be approximately 237,230 tons or 13.21%, thus there is a positive effect by the mandatory separation in Act 672. From this, it could be observed that there was a cost saving from reducing waste dumping in landfills of approximately RM7.12 million, based on the budgeted cost rate of dumping in landfill to be about RM30 per ton. This shows that about 13.21% of people do separation of their waste. This is because people still lack awareness of doing waste separation at the source.

In this research, the opinions of respondents about people's awareness of separating waste were the same. All respondents agreed that people are still not aware about this regulation because the mandate is still relatively new and the knowledge of separating waste is still not spread evenly to every person in Malaysia. Some respondent think that spreading the knowledge of waste separation must be done continuously to every person, for example, by giving talks in an event or in social media, as well as establishing policy and enforcement of waste separation in every house. Hopefully, it might increase the awareness of separating waste among all people in Malaysia.

Modern Trash Detection Machine Aspect

In this section, the researcher explained to the respondents that this research has developed an advanced technological system for separating waste and it might improve the people's awareness about separating their waste at home. Hence, the researcher asked them several questions about this machine and their opinion. The first and second respondent stated that, if there is a technology for separating waste automatically, it cannot be installed in every house because of the limited budget, and the technology might be expensive, so the householder may not be able to afford it. If the technology is cheap, then it will be fine. They also gave their opinion that, it might possible to install these machines centrally, with the help of local government. For example, the local government may install five technologies in a city, especially in a public area, where the technology can become a checkpoint and store the recycled waste. Other five respondents thought that the machine will help because a lot of work can be done by the machine instead of performing the separation manually, but the machine can only be successfully implemented together with the awareness and knowledge. If the machine is going to be implemented in many households, it would be good, but this is unlikely since it is a big challenge because of the cost.

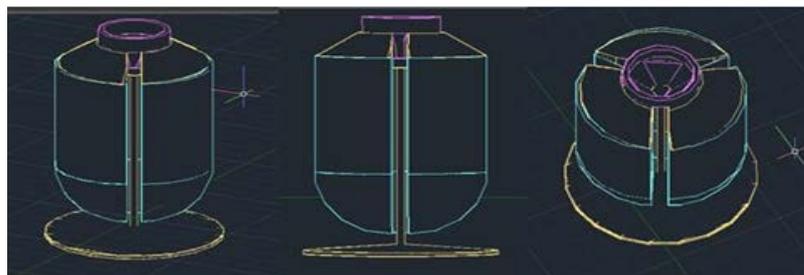
In relation to positive impacts the respondents replied that, generally the modern trash detection machine can help to make the society greener. On the one hand, it also helps to create new business that may increase economic development and quality of human life. On the other hand, the negative aspect is about the budget, since it may require more budgets to install. In addition, if people still do not have the awareness even when the machine has already been implemented, the general public still could not make any sense of the machine, and thus the machine would not be used effectively.

System of Auto-Sorting Waste Detection

The Machine Model

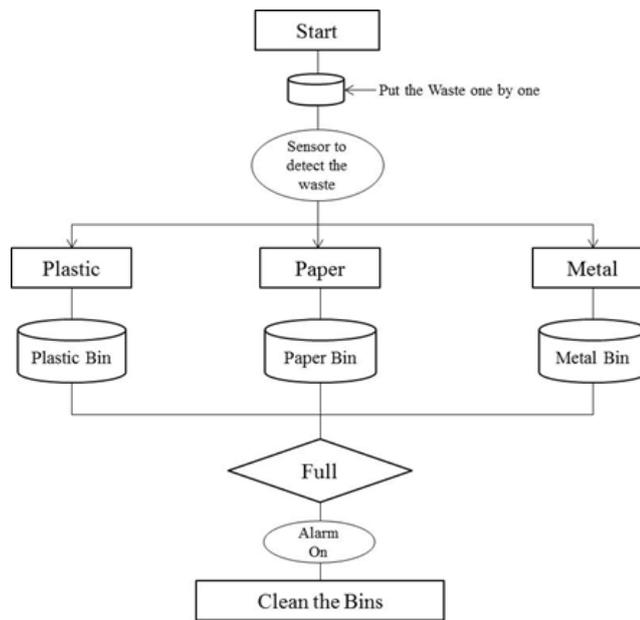
The researcher used AutoCAD software to design this machine (Figure 2). In this design, the modern trash detection machine is divided into three bins, which are plastic, paper, and metal bins. This machine is designed with the simple and unique model to make people attracted to the design of the machine, thus making it more attractive for use.

Figure 2
Design of the modern trash detection machine



As can be seen in Figure 2, there are three views of the modelled machine in AutoCAD. At the top of the machine (purple coloured), there is a sensor, where the waste is inserted and the sensor is able to detect whether the waste is paper, plastic, or metal. There are three bins (blue coloured) which are quite large enough to store the waste, and at the top of these bins are the cover that can be lifted to clear the bins when they are full. There is a large circular stand at the bottom of the machine to make it stable and sturdy, being able to support the weight of the bin and recycled trash. Figure 3 shows the process flow of the machine.

Figure 3
The process flow of the waste separation machine



The Modern Trash Detection Machine

In Figure 3, the system is shown as the work process of the machine, where firstly, the user puts the waste into the top of the machine. Then the machine will detect whether the waste material is plastic, paper, or metal, using a built in sensor installed at the top of the machine. If the waste is plastic, it will go through to the plastic bin, and same goes for the paper and metal wastes. In addition, when the bins are full, the machine will turn on the alarm automatically in order to alert someone that the bins are already full. Lastly, emptying the bins need to be performed by an individual in order to make the machine ready to be used, which needs a person who has knowledge on how to perform this manual maintenance step since it is not automatic.

IMPLEMENTATION

The auto-sorting waste detection machine has a huge application potential in national, social, and economic aspects. In general, if the separation process goes well, it can extend the age of the landfills. Normally, the duration of landfill to be full is around 20 years. However, if this machine makes people separate their waste more, it will reduce the waste that directly goes to the landfills, because the waste will be recycled and can be used again as a useful resource. As a result, it will make our society

greener. By introducing this machine, it can create a new business opportunity. Hence, many entrepreneurs may be interested to make a business venture into this recycling area, which could become an additional source of generating national economy, improve human life quality, as well as reducing the unemployment problem. In addition, it will assist the government in decreasing the import of raw materials that can or cannot be renewable, such as paper and plastic (renewable) and fuel, oil, coal, etc. (non-renewable). Finally, if we can handle the recycled waste properly with the awareness and auto-sorting waste detection machine, then it will be helpful for protecting the environment, which is the most urgent issue nowadays all over the world.

CONCLUSION

The environmental problem is a critical issue that is faced by every country, especially in developing economies such as Malaysia, Indonesia, India, Thailand, Bangladesh, and others. Focusing on Malaysia, a few years ago the country experienced uncontrolled consumption due to the increasing population that contributed toward an expanding waste generation rate, which had increased quickly every year. Moreover, solid waste generation increases at an uncontrollable rate due to the dispensable utilisation of plastic and paper materials used for packaging. This problem occurs because Malaysia still lack public awareness, environmental education, technical skill, and appropriate technology regarding the importance of involvement in the recycling programme. The Malaysian government is committed to improving solid waste management to achieve Vision 2020. Waste Minimisation Master Plan (WM-MP) is committed to introduce the minimised consumption of natural resources and minimise the reduction of environmental load by enhancing the awareness on waste minimisation, strengthening partnership in 3Rs activities, and enhancing institutions to strengthen government policies on waste minimisation. Therefore, innovation to make improvements by using advanced technology is needed to reach the goal of Act 672, which is to ensure a proper waste management system by increasing the number of people doing separation at the source in order to make recycling more effective and efficient. This paper proposed an auto-sorting waste detection service system, which is one initiative for meeting the national goals as a green society. Future research efforts are needed to make this technology to be implemented in the real life situation.

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