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Development of Identification System of cans And Bottle

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Abstract. The objectives of this research was developed an integrated simulation model of an intelligent sorting system based on machine vision, which is focused on object detection, identification and automatic sorting system of cans and bottle. In this research we used 60 cans and 40 bottles for database with five direction of each sample (upper, bottom, diagonal left and right side). Performance of the identification system for correct cans and bottles are 91.33% with estimated amount of 21,600 items per hour. The success of the identification depends on the size and type of the objects.

1. Introduction

Recycling of solid waste has a big challenge in sorting areas around the world. Without solid-waste sorting system effective and efficient, recyclable solid waste from various human activities have a negative impact on the recycling business. Recycling of solid waste problem in developing countries, such as Indonesia, has a number of aspects related to them, such as technological, official, financial, environmental and communal aspects.

The recycling of solid-waste cost billions each year, for example recycling a ton of aluminium saves the equal in energy of 2,350 gallons of petrol. This is equal to the total of electricity used by the basic home over a period of 10 years (www.aluminum.org, 2009). In 2004, whereas only 51.2 percent of beverage cans were recycled in USA, which is equivalent of energy about 15 million barrels of oil [Aluminium Association, 2009].

Sorting of reusable waste is a main stage in recycling industry. In developed countries, such as USA, Europe and Japan, traditional sorting systems are still usual methods when used to recyclable items. However, nowadays, the development and improvements of automated sorting methods are actively carried out using more scientific ways. In Indonesia, recycling plan is still at its beginning step. Public understanding on the importance of recycling waste is relatively too low. Hence, the goal of the future research is to develop an automated identification and sorting system of recyclable containers (cans and bottles) that utilizes an intelligent machine vision system. The future system is significantly

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contributing towards providing an efficient and cost effective method for sorting recyclable containers, saving of resources, reduction of ecological pollution and build-up of landfills.

Cans and bottles are one type of non-degradable materials in the solid waste. In fact, recycling cans and bottles have a number of significant environmental benefits, including reducing waste, reducing landfill and reducing greenhouse gas emissions. Table 1 shows number of waste production in 2008.

Table 1. Estimation of Waste Generation by Composition

Type of Waste	Amount (million	Percentage (%)
Garbage	22.4	58%
Plastics	5.4	14%
Papers	3.6	9%
Others	2.3	6%
Woods	1.4	4%
Glasses	0.7	2%
Rubbers / Leathers	0.7	2%
Fabrics	0.7	2%
Metals	0.7	2%
Sands / Inert Material	0.5	1%
ALL	38.5	100%

Waste quantity collected from household is greater than other non-household sources. Waste quantity collected from each sources is estimated (Figure 1). The question asked to fill out the data from last 5 years at least.

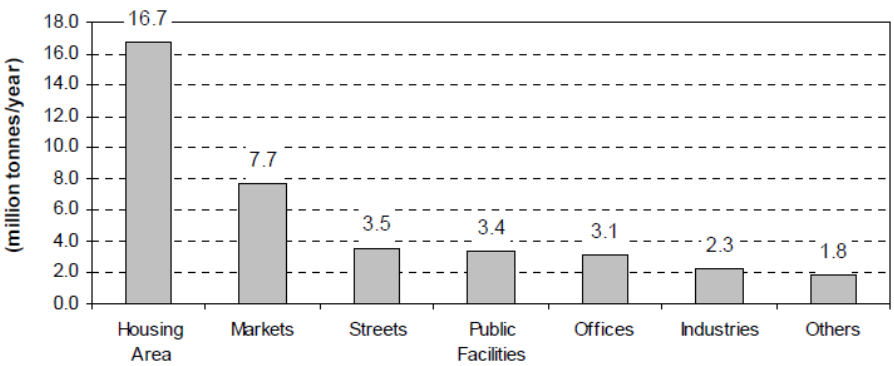

Figure. 1 Estimation of Waste Quantity Collected by Local Government

2. Sorting System

In any recycling activity, sorting of reusable waste is the first and most important step. Many developed country such as USA, Japan, and so countries in Europe are common still use manual sorting system as method of sorting recyclable items. However, work on the development and improvements of automated sorting are actively carried out (M. Ebner 2009; G. Pingju et al. 2008; D. A. Wahab et al. 2003). Out of many technologies, imaging technologies such as infrared, near infrared, sensors, X-rays and optics have been deployed in the development of automated sorting system. While the research and development of containing sorting based on the shape, size and colour characteristics generally is still ongoing.

Many approaches have been proposed for development of an intelligent sorting system which involves object detection, classification and position based on image and signal processing (Vetter, Poggio, et al., 1992**;** Sung and Poggio, 1994**;** Sinha, 1994**;** Moghaddam et al., 1995; Rowley et al., 1998; Aparna et al., 1999**;** Yang, 2002**;).** However, lighting condition, image variation, false detection rate, data acquisition in complex background, real time implementation and capturing the entire area are still posing a number of challenges for recyclable and non-recyclable object detection and classification (Y. Irsyadi et al., 2009; E. Scavino et al., 2009).

1.1. Manual Sorting System

Many countries including Indonesia (www.aluminum.org, 2009), waste cans are sorted into different types using manual sorting system. In the manual sorting systems, sorting and separation of alumina cans and non-alumina currently requires extensive manual process used to remove contaminants such as glass, plastic bottles, dirt and other non-metallic materials. Furthermore, the waste can be washed by the merchant waste cans and then sent to the recycled industry, where waste can be separated again according to the type of waste alumina cans, non-alumina cans and non- recycled cans.

The manual sorting faces some major problems such as labour intensive industry which incurs relatively high processing cost, Inconsistent quality of end products, skill And commitment essential for efficient sorting. As such, There is a need to maintain a relatively stable and skilled work team. The high processing cost does not only involve wages, pensions, and insurance payable for crew members working on the production line, but also the expenses on health and safety facilities. Labourers working at the manual sorting facilities are exposed to microorganisms, organic dust, and fungi, which can cause severe infections (Waste Cap. 2008). Hence there is an important need to automate the sorting process for efficient safe and clean recycling.

1.2. Automated Sorting System

The Automated sorting systems are classified into mechanical and optical. Mechanical sorting is based on the difference of physical features between fibre materials and other contaminations (non-fiber e.g. plastic and glass bottles, metals, cardboard). Gravity, size, shape, magnetization, and conductivity are considered as physical features. Recovered cans from a commingled waste stream are generally composed of a range of object sizes, shapes, thickness and stiffness. Finally it seems that the mechanical sorting is inadequate for achieving commercially viable throughputs and accuracy.

The greatest advantages of an optical sorting systems include: consistent and reliable efficiency of production with a relatively high hit rate and purity; and low operational cost due to reduced number of manual workers on the production line example.

3. Procedure For Identification System

The procedure for the identification of cans and bottle consist of a series of computational steps which are conventionally identified as image acquisition, image pre-processing, feature extraction and identification. Each of these steps is described in the following; an example of pattern recognition of an actual object is presented.

The first step in the pre-processing block is to take the image from inspection zone after trimming unnecessary boundary portion of the image. After that, the background noise is eliminated from the image using combined operation of threshold and morphological operation erosion with 7×7 minimum convolution filter.

The features extraction stage consists of quantization of image, calculating co-occurrence matrix and calculates energy in different quantization levels. In feature extraction phase, both colour and grey scale images are considered. For colour image each of the three colour components - red, green and blue - are considered separately. For grey scale image, standard grayscale transformation is obtained from the original RGB image

The image is then normalized; the edges are extracted and stored as a logical image. Sometimes, if the edges are not closed due to lack of contrast in the image, the system closes the missing points in order to get a better picture. To store the image in normalized form, the normalization conditions are as follow:

- The object placed right in the middle on the conveyor belt.
- Background of the conveyor belt is black.
- Lighting for each position tried to be kept the same.
- Distance between the camera and objects is 60 cm.
- Webcam resolution used is 100 x 100 pixels.

Matching process is undertaken by comparing the value of the object with the values in the database to find the closest values

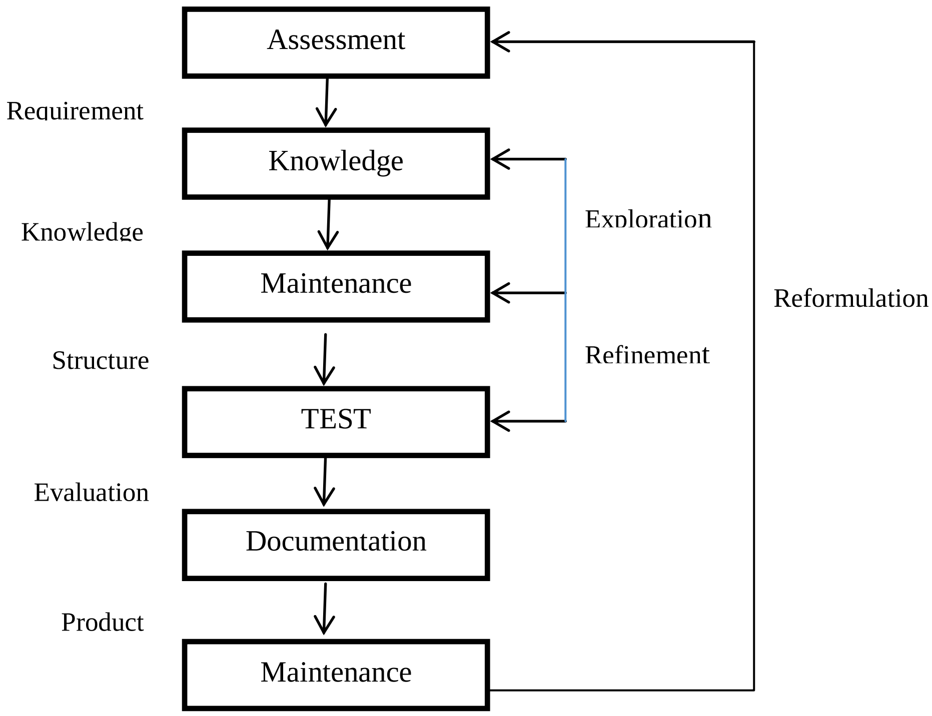

Figure. 2 Stages of Development of Expert System (Durkin, 1994, p. 40)

4. Development of The Automatic Sorting System

The sorting system configuration has two main modules, namely, identification module and the sorting module. In this section, the two modules are presented and described by giving details on the related theory and functional methods.

The procedure ("Pattern recognition") for the identification of a beverage cans consists of a series of computational steps which are conventionally identified as:

- Image acquisition

- Image pre-processing
- Feature extraction
- Pattern recognition

Each of these steps is described in the following; an example of pattern recognition of an actual beverage cans is presented. This procedure is meant to operate in real time while cans and bottle samples are travelling on the conveyor belt; thus, all the stages have been featured to be as fast as possible and other reliable but slower techniques (one example is the Fourier analysis of the image) are not included.

Once an object on the conveyor is detected by a webcam, the webcam automatically capture a picture and send it to the PC. The procedure is:

- Connect webcam to the computer through the USB.
- Show window to view Image at runtime
- This will open a small window Webcam interface
- Automatic Capture image
- Capture the image of that direct into the variable data.

Some factors, such as lighting conditions, speed of the conveyor belt, camera gain, contrast and brightness, height of the camera above the object, may strongly influence the quality and sharpness of the final image; experiments are carried on in order to find an optimum configuration. The image of a cans or bottle on the conveyor belt is shown with a resolution of 320*240 pixels and low lighting conditions. The white circular objects appearing at the top and bottom of the image are the supports of auxiliary lights, not used in this image

Image with background noise, due to the irregularities in the image scanning and capturing, should be processed for good performance of the system. Threshold technique is used for background noise elimination

The edge detection is performed on each colour ("layer") R, G and B in order to be independent of the colour and intensity of the background. An edge being in general a sharp change either of colour or intensity or both, also internal edge are found in the first part of this procedure, but subsequently removed. In the beginning, each layer is filtered with an averaging mask in order to avoid the edge detection of single spikes in the brightness. The edges in the filtered layer are detected by means of a modified Sobel mask of size 7x7 which proves to be more reliable than the standard 3x3 mask when the edges are not sharp and the brightness of the layer grows over a distance of many pixels. The edges obtained for each of the 3 layers are combined in order to obtain the final raw edge image.

An object in the binary image is identified by a complete closed edge made of a sufficient number of pixels. For sake of simplicity and speed the minimum number is taken as a fraction of the minimum perimeter among the cans or bottle in the database. However, the analysis of very small edges would just be time consuming without producing false positives in the identification of cans or bottles.

The edges of an object are discarded if they touch the boundary of the image, as the correct feature extraction would be prevented by the lack of a part of the object in the binary image.

In Sobel operator method, a mask is used to compute G_x at the center point of a 3×3 image region. Whereas, a similar mask is used to compute $Gy_.$ These masks are often referred to as Sobel operators. Figure 3 shows a grid of 3×3 image and its associated G_x and G_y operators.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

(a)

–1	–2	–1
0	0	0
1	2	1

(b)

–1	0	1
–2	0	2
–1	0	1

(c)

Figure. 3(a) 3 × 3 image region; (b) mask used to compute G_x at centre point of the 3 × 3 region; (c) mask used to compute G_y at that point. These masks are often referred to as the Sobel operators.

In the experiment, it is observed that the performance of the vision system is extremely influenced by the lighting arrangement. For calibration and adjusting the lighting, three different lighting techniques namely front lighting-directional-bright field illumination, front lighting-directional- dark field illumination, and diffuse front lighting are considered in this study. In both front lighting-directional-bright field illumination and diffuse front lighting, the images from the inspection zone show some reflection problems such that the beverage cans object on the conveyor belt seems to be. Moreover, the reflection from the surface of the object is not uniform. It is important that the texture information of the objects is analysed. Even one object of the same colour in whole body showed different colour combination in histogram analysis of the segmented portions of the image due to non-uniform lighting. In front lighting-directional-dark field illumination, image from inspection zone is distinctive for texture analysis and the object surface is illuminated uniformly. Moreover, front lighting-directional-dark field illumination is widely used in surface scratches or texture analysis (Pham D.T., & Alcock, R. J., 2003; Burke M.W., 1996), thus, this illumination technique is adopted for this experiment.

Since we have proposed a method of cans and bottle identifications system there is no standard data bank on which we can verify our method. So, the first task was to create a database of the object. We have collected 5 photographs for each of 60 cans and 40 bottle type. In order to store the feature values, a database with two tables has been created using Excel. One of the tables is used to store raw sample data images and another is used to store the template data.

In this section a relative comparison is made based on the outcomes of our proposed method for cans and bottle with different resolutions. Cans and bottle must be identified considering only one component out of Red, Green and. When we consider other grades of cans and bottle then it is essential to combine three components to make robust decision in cans and bottle type selection.

The correct identification rate is calculated based on the percentage of the number of objects are classified into their respective type. When the window size is 3×3 then achieved classification success rates are 88% for cans and bottle. When the template size is 7 × 7 then the achieved average classification success rate is 91.33%. In order to get the optimum performance in terms of classification success rate and computation time, the suggested window size is not greater than 8×8.

Table 2 Identification Succsess Rate

Object	Object	Success Rate (%)
	Cans	93
	Cans	80
	Cans	100
	Cans	100
	Cans	86
	Bottle	100
	Bottle	100
	Bottle	86
	Bottle	86
	Bottle	80

5. Conclusion

The major importance of this study is on the development of cans and bottle identification method for automated sorting system. The identification system performance for correct cans identification is 91.33% with estimated throughput of 21,600 things per hour. The success of the identification depends on the size and type of the objects. The most important point addressed in this work is that the method, which uses computer vision, can be implemented easily to sort multiple types of solid waste, (cans and bottles). Further work should focus on to other solid waste sorting, such as paper, plastic, and glass. Finally, identification system with edge detection method is recommended to use for automated sorting system of the solid waste.

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