Detection of immovable objects on visually impaired people walking aids

Abdurrasyid Abdurrasyid*[1], Indrianto Indrianto[2], Rakhmat Arianto[3]
Informatics Engineering/Sekolah Tinggi Teknik PLN,
Menara PLN, Jalan Lingkar Luar Barat Duri Kosambi Cengkareng Jakarta Barat, 11750, Indonesia
*Corresponding author, e-mail: arasyid@sttpln.ac.id[1], indrianto@sttpln.ac.id[2], arianto@sttpln.ac.id[3]

Abstract

One consequence of a visually impaired (blind) person is a lack of ability in the activities related to the orientation and mobility. Blind person uses a stick as a tool to know the objects that surround him/her.The objective of this research is to develop a tool for blind person which is able to recognize what object in front of him/her when he/she is walking. An attached camera will obtain an image of an object which is then processed using template matching method to identify and trace the image of the object. After getting the image of the object, furthermore calculate and compare it with the data training. The output is produced in the form of sound that in accordance with the object. The result of this research is that the best slope and distance for the template matching method to properly detect silent objects is 90 degrees and 2 meters.

Keywords: image processing, object detection, template matching, visual impairment, walking aids

1. Introduction

Visual impairment can be classified according to the maximum ability of the sensory correction of vision to light entering the eyes. The definition of blindness according to the World Health Organization is the ability of maximum correction of vision of the sense of vision possessed by a person less than 20/500 or has a visual field of less than 10 degrees so the brain can not receive information about objects and light coming into the eye [1]. Impaired vision can cause humans unable to perform daily activities such as driving vehicle, reading text, socializing with others, and walking to a certain destination.

To improve the mobility of the visual impairment, some researchers try to help by developing electronic travel aids (ETA) available in various forms, such as: handheld devices, smart canes, wearable system, and image-based detection. However, the rate of use of ETA for visually impaired people is quite low [2]. This condition is not caused by the resistive action of visually impaired people towards ETA, but more due to the function and usefulness of ETA that does not meet the needs of its users so that required further development. This can be proved by the lack of visually impaired people using ETA.

The guidelines of the National Research Council states that the ETA developed tools should assist in terms of detecting obstacles that exist in the lower and upper part of human body to achieve a level of mobility that is safe, understand the surface structure, and give travel information. It should also deal directly with the natural sensory channels [3]. Some existing ETAs, have adopted some parts of the guidelines. Some examples of existing ETAs, such as NavBelt [4] that use robots to help visually impaired people to know the circumstances around as a substitute for pets but requires the effort of the user to understand the sound issued by the robot. There is also ETA that utilizes ultrasonic sensor technology such as GuideCane [5]; a cane that is used by visually impaired person to detect the surface level of the road in front of it and the objects around it. K-Sonar Cane [6]; this tool uses sound wave technology to detect the distance of objects around its users and the tool will give a warning in the form of sound so the user must really pay attention to the sound and separate them from the other sounds around. Research that has just been published with the name of smart blind stick [7] this research uses smart canes that only have two functions which are to classify an obstacles height whether it is low or high and to detect a front hole. There are some deficiencies on some previous researches such as, instead of giving the blind people an audio output, they only put a "beep" alert, in which, at the end [8], those people cannot recognize the object in front of them. Ultracane [5] is a cane tool that uses ultrasonic waves to detect floor-level and head-level obstacles,

and Electronic Mobility Cane (EMC) [2]; a cane-moving tool that detects floor-level and knee-level obstacle by positioning the cane to be held straight. When EMC is used diagonally or skewed, it can reduce the device's detection of obstacles in front. Likewise, with some other tools using echolocation technologies such as CyARM [9], the sonic torch [10], and kaspa system [11, 12], this system requires users to constantly advance their hands to recognize obstacles around them. In addition some ETA technology using the imaged based recognition such as the use of 3D-CMOS to detect object by the image capture sensor however can not recognize detail object [13], RGB-D image-based detection of stairs, pedestrian crosswalks and traffic signs [14], and to help blind persons read text labels and product packaging fromhand-held objects in their daily lives [15] However, from the result of the research, the equipment fails to recognize some objects, like stairs, a bump, or a hole.

Based on some literature review, this research will build a tool that is intended for visually impaired people by using a small bag that can be used anywhere and have a camera to detect obstacles around. This camera will take a picture that is in front of the user and recognize whether there is a moving object so that it can prevent the user to bump into it. Images taken by the camera will be processed using Template Matching method have been used with great success over the years as image processing method [16], this method used to recognize obstacles and suggest a sign that should be performed by the user, this method have several benefits such as low storage requirements and its effectiveness when the amount of training data is limited [17], furthermore this method accurate enough to detect objects but no one has used this method on walking aids to help the blind, although this method has been used to identify boards of Scots pine to enables tracking of individual boards through an industrial process [18], Rajithkumar and Mohana used the algorithm to recognized the stone Inscripted Kannada Characters of Different Time Frames Based on Correlation Analysis [19], Bao used template matching algorithm to recognize the object of cucumber where this method is embedded on the harvesting robot [20], Pham used the method for object recognition in infrared video sequences [21], and Principi used the method to so based on some literature review above it can be said that this research has novelty in science on how the template matching method can be effectively used to help people to identify and recognize some silent objects.

2. Research Method

The research was conducted in several illustrated phases, such as: user requirement collection, literature study, hardware design formation, implementation of design results, trials, and conclusions. The collection of user needs is done by interviewing visually impaired people about the walking aids being used. Literature study is done by studying some research on visually impaired people walking aids and also research related to Template Matching method. Hardware design is done by collecting the need for tools built and assembled virtually first. The next step is to arrange hardware such as power bank as power source, Ultrasonic Sensor HC SR-04, Raspberry Pi 3 V2 Camera, Raspberry Pi 3 Model B, and earphones so that it can function well. Stages of testing tools that have been assembled, done by providing several different cases so it can know the limits of the ability of the tool assembled.

This research uses Template Matching method in which this method is one technique in digital image processing that serves to measure the level of similarity of the input image to a picture as a template by comparing the pixel intensities. The Raspberry camera will take a picture when the ultrasonic censor detects the distance between an object and the user (blind people) is less than 3 meters, where the distance will give the Raspberry mini PC some time to process the picture and also give the time for the user to avoid the object. After it gets the picture, then the template matching method works. the work procedure of the template matching method is by comparing the pixels from the picture taken with the pictures on the data training database so that the comparison result will out; the smaller the SAD value, the more similar the objects compared. Thus, it will recognize the object that is being detected. The formula of the Template Matching method is written in (1) where SAD is Sum of Absolute Difference measure, A pixel in the search image with coordinates (x_s, y_s) has intensity $I_s(x_s, y_s)$ and a pixel in the template with coordinates (x_t, y_t) has intensity $I_t(x_t, y_t)$. Thus, the absolute difference in the pixel intensities is defined as $Diff(x_s, y_s, x_t, y_t) = |I_s(x_s, y_s) - I_t(x_t, y_t)|$ [22]. This method is commonly used in several purposes such as quality control [23], as navigation moves the robot [24], and detects the edges of the image [25].

$$SAD(x,y) = \sum_{i=0}^{T_{rows}} \sum_{j=0}^{T_{cols}} Diff(x+i, y+j, i, j) \tag{1}$$

At the design stage of the tool, the RES [26] practicum module is used where the module contains the steps needed to design a microcontroller and it has been proven that the module can improve the level of understanding of the students of Sekolah Tinggi Teknik PLN to the field of microcontroller so it is suitable as a reference to design microcontroller which consists of Power Bank as an electrical supplier, Raspberry Pi 3 as a mobile computer, Ultrasonic sensor as a measure of the distance between users with obstacle, Raspberry Pi camera V2 as image capturing, and earphones as a medium of speech that will be heard by the user. The design of the hardware can be seen in Figure 1.

3. Results and Analysis

We proposed the design hardware that has been determined, can be seen in Figure 2. Where Ultrasonic Sensor HC SR-04 is used to measure the distance from the user against the obstacle in front of him/her. When the distance between the user and the obstacle is 3 meters, Raspberry Camera Pi 3 V2 will work to capture the obstacle and save it in Raspberry Pi 3 Model B. Then the image will be processed using Template Matching method. The result will show how many image correlations are captured by the camera with a picture that is used as a template (training picture). Raspberries will send output to earphones in the form of sound with voice "*awas ada pintu*" (beware of the door), "*awas ada tangga naik*" (beware of the ascending stairs), "*awas ada tangga turun*" (beware of the decending stairs), and "*awas ada dinding*" (beware of the wall).
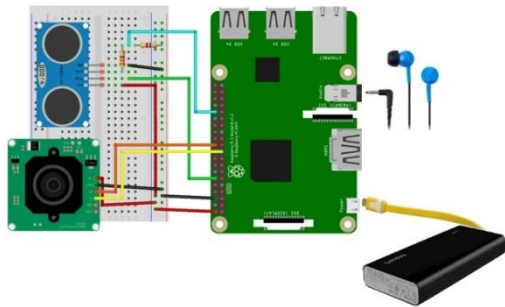

Figure 1. Hardware design   Figure 2. Proposed of hardware design

Before this tool is used, it should be inserted with some images as the training data. In this study, we added several types of pictures such as wall, ascending stairs, descending stairs, and door pictures. Images that are used as the training data will be processed into grayscale images and stored in Raspberry Pi 3. Examples of images used as training data can be seen in Figure 3.

(a)   (b)   (c)   (d)

Figure 3. Training data example: (a) data training door (b) data training ascending stairs
(c) data training descending stairs, and (d) data training wall

Testing the use of the tool is done by using Raspberry Camera which is taking some pictures around the place of research. As in Figure 4 (a) where the picture taken can detect the wall, while in Figure 4 (b) it can detect the descending stairs with the similarity obtained on the handrail of the descending stairs marked by a handle that leads downwards. Figure 4 (c) can detect an ascending stairs with the similarity obtained on an ascending stairs handlebar marked by an ascending staircase, while in Figure 4 (d) it can detect a door with similarity to the door picture and it can be detected well.

(a)　　　　　　　　　　　　　　　　　　(b)
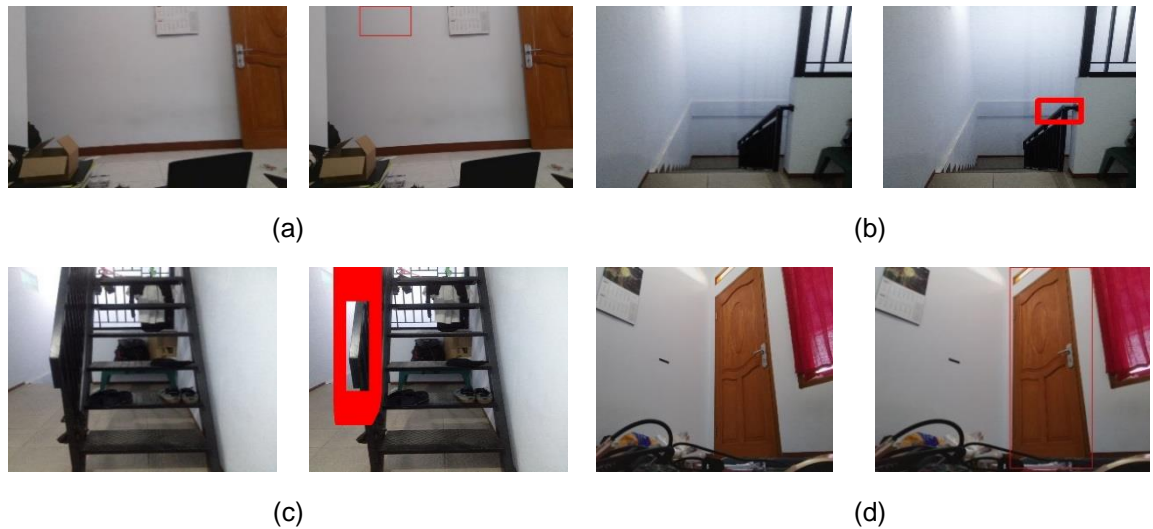
(c)　　　　　　　　　　　　　　　　　　(d)

Figure 4. Some test result

After some initial trials, some additional trials were added by adding training data into 4 types of doors, 4 types of ascending stairs, 4 types of descending stairs and 4 types of walls. Then, the test on the tool was done with different distances starting from a distance of 3 meters, 2 meters, and 1 meter. Each distance of the picture taking will be done with a slope of 45 degrees, 90 degrees, and 135 degrees. The results of these trials can be seen in Figure 5.
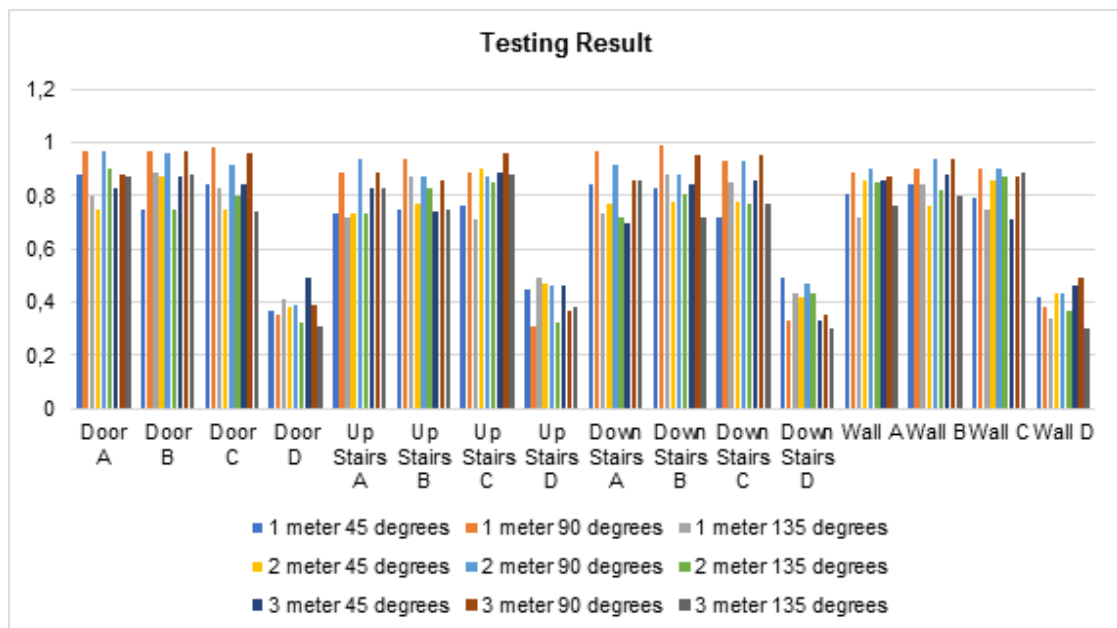
Figure 5. The result of testing with conditions

It can be said that the result of this research is that the Raspberry Camera that is effectively embedded with template matching method gives the descriptions of the condition, distance, and slope which can be seen at Figure 5 shows that the tool accuracy results in some conditions where category D and gets the condition when the captured image is an image that has a level of difference up to 50% of the previously stored image so that it always gets accuracy below 50%. In the A, B, and C categories, we used images that are almost similar to the existing images in the training data and taken with the slopes of 45 degrees, 90 degrees, and 135 degrees. The best results are obtained with a slope of 90 degrees where the camera can take a very clear picture and have little noise on the image. For the slopes of 45 degrees and 135 degrees, we have smaller accuracy result but can still give a warning to the user because with the condition of the slope, the image taken has some noises, this kind of test has never been done by the previous researches, especially by those who exercise the template matching method to help the blind people to walk.

4. Conclusion

From the results of the research conducted, from the initial stage until the testing process, it can be concluded that to create or build a camera tool model of silent object detection in this study is done through a system development method called template matching method. The design of this research consists of hardware design which is built using main tool components such as Raspberry Pi 3 Model B, Raspberry Pi V2 Camera, HC-SR04 ultrasonic sensor and earphones. This tool works when there are obstacles detected, the camera is instantly capture when a barrier is detected. The Raspberry processes the image captured and the train data. The results of the image captured and the train data is processed. When there is a match on a picture on the train data, e.g. the door, the handsfree sounds alert of door. Then and all components of the tool such as raspberry pi v2 cameras, ultrasonic sensors, and the handsfree will work according to the order of Raspberry or according to the state of the appliance. The result of the template matching method performs comparison of the object using the previously input train data and the result of a sound output that warns the user whether the result matches and does not match.

From the result of testing with conditions shown above it can be conclude that the best results for the template matching method can work with fairly good results, even though the dataset is not available so much when in slope conditions of camera are obtained with a slope of 90 degrees where the camera can take a very clear picture and have little noise on the image, and the best distance that the template matching method can detect silents objects well is 2 meters. For the next research, we need to add the number of images as the train data because the Matching Template algorithm is very dependent on the number and variation of the stored image as training data to be able to recognize more obstacles, when the image taking process of an obstacle must be clear and focus because if the image gets blur, then the object in the image will not be detected, and the need for a certain algorithm that can stabilize the camera when the tool is used while walking.

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