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Face detection and global positioning system on a walking aid for blind people

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ABSTRACT

Blindness is a general term used for the condition of someone who experiences a disturbance or obstacle in their sense of sight. In general, blind people walk with special canes to help them walk and increase their safety. However, there are problems that arise when blind people walk home or go from a path that they are used to or to a place where they have never traveled. There is the possibility that blind people get lost and find it difficult to determine their way home because they don't know where they are going. For this reason, it is necessary to create a system that can monitor their whereabouts in real time and provide directions, provide information on the steps to their destination and they can also notify their families and related foundations if they are in trouble. For this reason, it is necessary to make an integrated tool with the haar cascade method to detect faces to find out whether there are humans or other obstacles that can shows 94% accuracy, in addition a global positioning system (GPS) can help blind people to show the direction of the destination.

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1. INTRODUCTION

According to the world health organization (WHO) a person is said to be blind if they have a visual acuity of less than 20/400 or a visual field of not more than 10° in a radius around the fixation center point in the eye [1], The sight senses function when light is processed by the eye and interpreted by the brain. Light passes through the cornea, then the pupil dilates or contracts, to regulate the amount of light entering the eye. Next, the light will be received by the retina and "convert" it into nerve impulses that can be read by the brain. This is a concern in every nation including Singapore and Germany [2], [3]

Based on statistical data released by the central statistics agency (CSA) in 2017, 6.4% of the total population of Indonesia has visual impairment [4] in accordance with the inter-census population survey [5], even in line with the overall Indonesian blind association stating the number of blind people in Indonesia. Indonesia has reached 3.75 million people and this figure can continue to grow in line with the rate of population growth in Indonesia, which currently reaches 1.2% per year.

The main problem faced by blind people is their damaged sight senses where it affects their daily activities. After having an interview about that, blind people will usually need assistive devices to carry out their daily activities such as walking, reading and others. From the government it self, Indonesia became one of the countries that signed the convention on the rights of persons with disabilities. The Law No. 19 of 2011 on ratification of the convention on the rights of persons with disabilities was ratified, which shows that the Indonesian government has given special attention and is trying to improve to help the blind people [6], [7].

Previously, many studies have been carried out with blind people as the subjects, where the visually impaired aids that are studied can be divided into 3 parts, robotic navigation aids, smartphones and wearable attachments [8], previous studies mostly used ultrasonic sensors and image processing, [9]–[11] but looking at the research that has been developed, it still has shortcomings, previous studies did not provide voice information to blind people on how far they are from an obstacle, what if there was a pothole or uneven road, when to avoid, which direction to avoid. A similar study was carried out by Gayathri using ultrasonic PIR sensors and global positioning system (GPS), but this study did not consider obstacles in the form of potholes or uneven roads and no scientific method was used in the research, especially in how the device works [12].

The research that will be carried out is to improve the research that has previously been done [13], [14] by integrating image sensors, using cameras using the haar cascade method to detect human faces in order to identify them when caught by the camera. This method is quite good at detecting faces as proven by the studies conducted [15]–[17]. Not only to detect faces, but this method is also quite good at recognizing objects such as security equipment in the work environment [18], detecting cow's milk on farms [19], and detecting vehicles in parking lots. Research by Hakim [20] there are also those who use deep learning to detect images [21], although it is widely used but it has not been used as walking aids for the blind and also the use of voice commands, the voice command feature is also widely used by researchers to help the visually impaired such as changing voice into text [22], voice becomes emoji [23], activates some apps in android [24], [25], or to open email [26], and send messages [27] there are some that specially made for Indians who do not speak foreign languages by using a desktop application called bangla [28], but there is none that is used to help blind people enter the desired location destination. It is also equipped with a panic button that can be pressed when blind people have problems that can provide coordinates so that the foundation officers can immediately go to where their members are experiencing problems.

This research provides benefits both for the visually impaired and the foundation that shelters the visually impaired, where the first is that the foundation can find out the condition of its members in real time so that when members face a difficult situation, foundation officers can immediately help, secondly, from the member's side, it can help members to find out surroundings and help determine the route you want to take.

The remainder of this paper is organized as follows; section 2 presents the comprehensive theoretical basis, which describes the theory about the method used in this research. Section 3 provides a research method. The experiment's findings are presented and discussed in section 4. Section 5 concludes with conclusions and recommendations for future work.

2. METHOD

The haar cascade classifier is a wavelet-based rectangular feature, which identifies a specific image. This method uses a statistical model (classifier). The 4 main elements combined for the approach to detecting objects in an image are haar-like features, integral image, adaboost learning, and cascade classifier [16]. The main idea of Haar-like features is the recognition of an object from the simple value of a feature but does not become part of the pixel value of the object's image [29], Haar wavelets are single rectangular waves (one high interval and one low interval). For two-dimensional (2D), it has one light side and one dark side [17] as shown in the Figure 1.

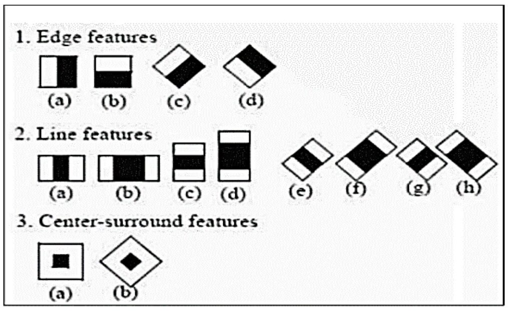


Figure 1. Haar-like feature

This method has the advantage of being very quick to compute because it only uses the number of pixels in a square rather than each pixel value in the existing image [30]. This method uses a statistical model (classifier). The key component of the haar cascade classifier is haar features. Haar features are used to find out whether there are any features in a particular picture [31].

The formula used in the Haar-like feature is:

$$f(x) = \text{SumBlack rectangle} - \text{SumWhite rectangle} \quad (1)$$

The existing Haar feature can be determined by subtracting the average value of a pixel in the black area from the average pixel in the white area. If the difference is above the threshold, then the Haar feature is available. The difference between the number of gray level pixel values in the white box and black box areas is the Haar-like feature value, which can be calculated correctly using a "integral picture" for the Haar-like feature box. Integral images are used to efficiently determine the presence or absence of a set of Haar features in an image at various sizes.

Figure 2 after integration, the pixel value (x,y) is the sum of all pixels that are in the rectangular area from the top left to the location (x,y) or the shaded area. To obtain the average pixel value in the rectangular area (shaded area) this is done simply by dividing the value at (x,y) by the rectangular area.

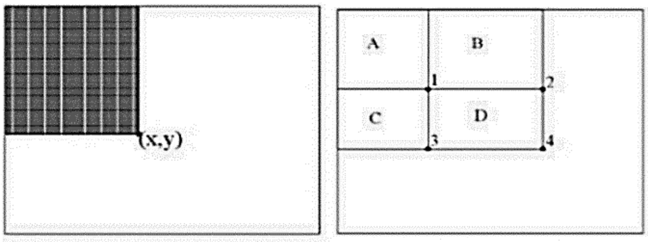


Figure 2. Integral image

Adaboost is an algorithm to combine many weak classifiers in order to get a strong classifier by combining Adaboost to assemble filters in order to process the classification of regions in the image. Adaboost creates powerful classifiers by combining weak classifiers in a linear fashion [31]. Each filter contained is a separate Adaboost classifier consisting of a weak classifier or one Haar feature. When the filter process is running, if there is one filter that cannot pass through an image area, then that area is included in the non-face category. However, if the filter passes through an image area and the entire filter process is in the filter circuit, then the area of the image will be included in the face group.

The next process is the cascade classifier. The order in the cascade classifier filter process is determined by the weights received from Adaboost. The filter that has the largest weight value will be processed first to remove the image area that is classified in the non-face group. The haar-like feature has a learner criterion and a weak classifier. To obtain a result that has a higher level of accuracy, it is necessary to carry out a process of Haar-like features with a large number, if the number of Haar-like features is higher, the accuracy level will be higher. Below is the workflow of the stratified classification.

The stages carried out in this research are as follows, the first is the initial stage of the research, the research begins by determining the need for research data and preparing the materials needed for the research, the second stage is conducting a literature study by collecting reference materials, especially from journals and proceedings. international research and development that has been carried out to enrich and find research gaps, the third is the software engineering stage carried out by planning this is the stage of collecting materials for software design including analysis of process requirements and software data requirements, then the design stage that changes the results of the analysis into a design form that can be understood by users, especially blind people, make a rough sketch of the model of the tool that will be made before it is finally converted into a real prototype of the tool at this stage it is also designed how to implement haar cascade on the tools that were built, followed by building the prototype, at this stage the sketch that had been made at the design stage was then realized into a series of tools before finally inserting the program line. Followed by the stage of making the coding program, followed by the acceptance testing stage obtained from the stories has been implemented as part of the tools release. The framework of thought can be seen in Figure 3.

Figure 3 shows how the framework of the research were carried out, where the input data indicators are taken from the location in the form of latitude and longitude points as well as facial images, where the location points are processed by GPS to get their location, while the facial image input is processed by the haar cascade method to detect whether the captured image is a face or not, and at the final stage of accuracy testing is used to measure the accuracy of location measurements and face detection which is the objective of this study. Figure 4 shows how the haar cascade method works in this study. Before entering the first stage, the Haar Cascade system will resize the image to a size of 24x24 with a pixel size of 288px x 384px as shown in the Figure 5.

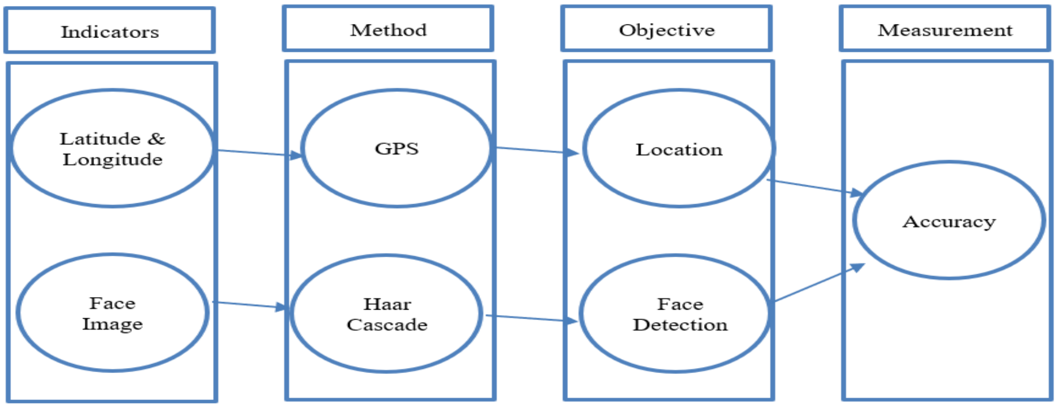


Figure 3. Research framework

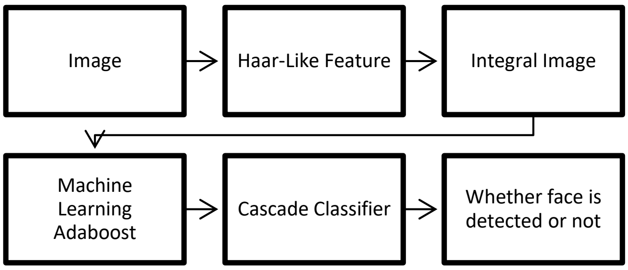


Figure 4. Stages of the haar cascade method

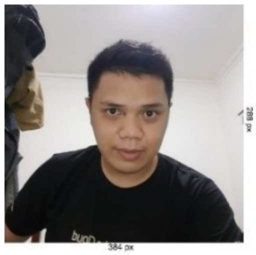


Figure 5. Image after resizing by Haar cascade

2.1. Haar-like feature

Haar-like features function as an image process to get the difference in threshold values that indicate dark and light areas. The value that has been obtained will be further processed in image processing. It can be seen from Figure 6, Haar like feature functions to compartmentalize the area of each pixel from top left to bottom right to look for any facial features in that area. Existing features are utilized to look for facial characteristics such as eyes, nose, and mouth in the haar feature selection process. Each feature box is made up of numerous pixels, and it will calculate the difference between the bright box's pixel value and the dark box's pixel value. If the difference between the light and dark portions is greater than the threshold, the area is said to have a feature.

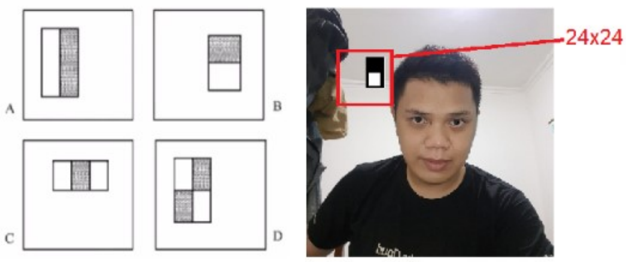


Figure 6. Haar like feature dan evaluasi wajah dengan ukuran 24x24

The next step in the Haar cascade process is to convert the image to grayscale so that the dark and light areas may be identified, as shown in Figure 7. In order to detect facial features, it will be easier to use features that match the eyes, nose, and mouth as shown in Figure 8. The evaluation calculation carried out is on a 24x24 image. At 24x24, there are about 160,000 Haar like feature forms. The evaluation calculation with 12 face sizes with each magnification of 1.25 scale is shown in Figure 9.

Figure 7. Color image changed to grayscale

Figure 8. Features on mouth, eyes and nose

Figure 9. Evaluation with 12 face sizes with 1.25 scale magnification

2.2. Integral image

With the concept of integral image, we can extract feature values from Haar-like feature much more quickly and efficiently. The calculation of pixels from the top left corner to the bottom right corner constitutes the integral image calculation as shown in Figure 10. To calculate an input image so that it can become an integral image, then the value of each pixel in the image is added to the top and left as shown in Figure 11. If the calculation has been done for each existing pixel, the results of the integral image calculation will be obtained as shown in Figure 12. After getting the results from the Integral Image, then it will be calculated for certain areas as shown in Figure 13.

Figure 10. Image entered in pixels of a feature

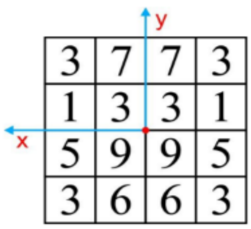


Figure 11. The calculation method converts the input image into an Integral Image

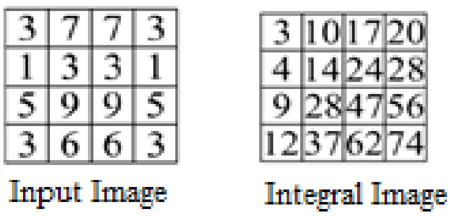


Figure 12. Result of integral image

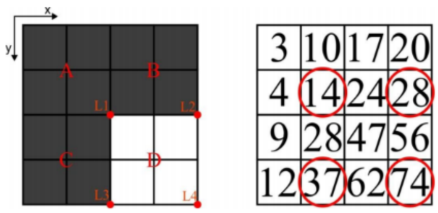


Figure 13. Pixel calculation in certain areas

To calculate the number of pixels in area D, the following formula is used:

$$D = L1 + L4 - (L2 + L3) \quad (2)$$

If the number of pixel values in a certain area has been obtained, then the results will be compared between the pixel values in the light and dark areas. If the difference between the pixel values in the dark area is above the threshold, then the area has a feature.

2.3. Machine learning adaboost

This technique serves to combine a large number of weak classifiers to form a strong classifier in order to classify an object. Furthermore, an image will be detected again with the Adaboost algorithm to find out if there are facial features in the weak feature classification area. In a weak classifier, a calculation and comparison with other classifiers will be carried out randomly and then combined with other classifiers to form a linear combination. The red circle above tells that it is a weak classifier while the blue circle shows a strong classifier. The area that has the weakest features is classified with the weak classification area. In Figure 14(a) it can be seen that the weak classifier features will be combined in order to increase the weight of the features so that they can form a strong classifier as shown in Figure 14(b). If there is still a weak classification in a feature even though it has been combined, then the area is still a weak classification and means there are no facial features as in Figure 14(c).

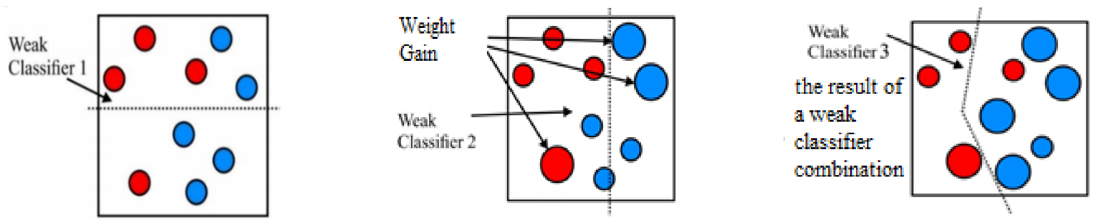


Figure 14. Type of classifier (a) weak classifier, (b) weak classifier combination, and (c) the combination result of the weak classifier

2.4. Cascade classifier

In the next stage, the cascade classifier processes many features in an organized way in the form of stratified classification. To be able to determine whether or not there is a facial feature in the selected feature, there are three classifications. The first is that each sub-image will be included in the classification with only one feature. If it has been processed and the result of the feature value from the filter does not match the desired criteria, it will reject the result.

Then the algorithm will lead to the next sub window and perform the process of calculating the return value. If the results obtained are in accordance with the predetermined threshold, it will proceed to the next filter stage. Until the number of sub windows that can pass the classification will be close to the image that can be detected. Figure 15 shows the cascade classifier process:

a. The first filter will select one classifier feature with a detection percentage rate of 100% and 50% error.
b. The second filter will select five classifier features with a detection percentage rate of 100% and 40% error (20% cumulative).
c. The third filter will select 20 classifier features with a detection percentage rate of 100% and 10% error (2% cumulative).

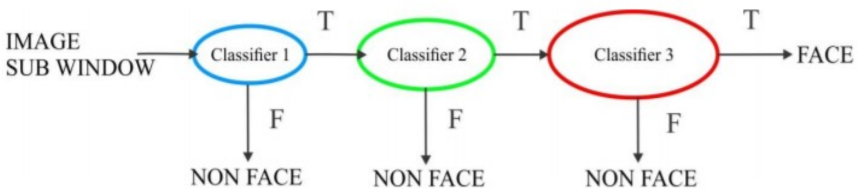


Figure 15. Cascade classifier

After all processes have been done, the detection results will be obtained. The results of the detection will be in the form of face or non-face information. If in the stratified classification process there is face detection, the image will be marked with a rectangle on the detected face as shown in Figure 16. Figure 17 shows the design of the tool that is made where as input, there is an ultrasonic sensor HC-SR04 to detect objects by reading the reflection of ultrasonic waves, then the camera will take an image when the ultrasonic sensor detects an object within 3 meters, a push button to send the current location. Button pressed where the location is obtained from the neoGPS sensor.

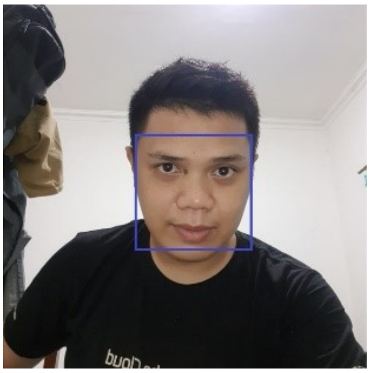


Figure 16. Detection results

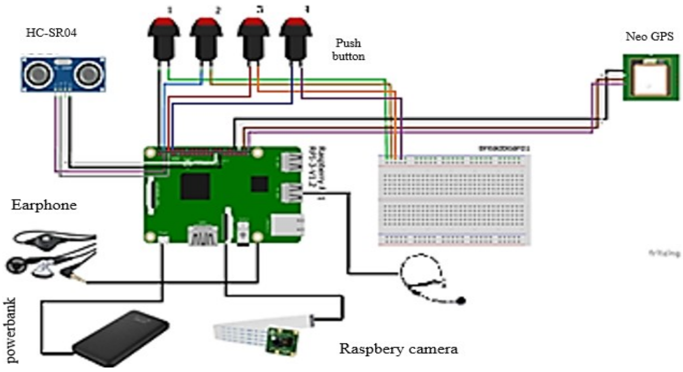
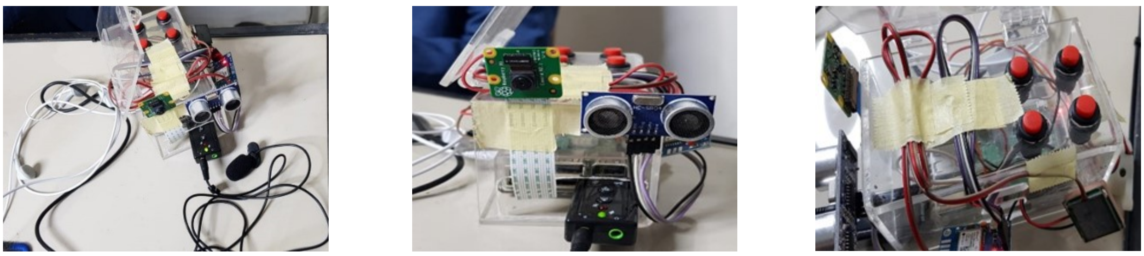


Figure 17. Device design

3. RESULTS AND DISCUSSION
3.1. Device design results

The walking aid for the blind in this study was designed using several hardware devices, namely Raspberry Pi, ultrasonic sensor, camera, push button, microphone, earphones, and Neo 7M GPS Module. The following is the result of the whole set of hardware used. Figure 18 shows the results of the design of walking aids for the blind, Figure 18(a) shows the overall design of the device, while Figure 18(b) shows the placement of an ultrasonic sensor and a raspberry pi camera where the camera will activate when the ultrasonic sensor detects an obstacle at 3 meters, while in Figure 18(c) shows a push button that will send the current location of the disabled. The visually impaired to the cloud server when the button is pressed.



(a) (b) (c)

Figure 18. Walking aid device design result (a) device design of the walking aid, (b) ultrasonic and raspberry pi camera and (c) push button

3.2. Device test results

Figure 19 shows the test results from the ultrasonic sensor where the test was done 80 times with a distance from 50 to 400 cm the sensor began to experience a decrease in function after the sensor distance >= 3 meters with a total of 5 failures so that an accuracy rate of 93% was obtained, this will certainly be different, when the sensors used have different qualities from those used in this study.

Tests were also performed on the ability of the haar cascade in detecting faces as shown in the Figure 20. The experiment was done 80 times with the intensity of light indoors with good lighting and outdoors during the day which has a fairly good level of light intensity, the same as the tests carried out on ultrasonic sensors, with a distance 50 to 400 cm, after testing it was found that the ability of the haar cascade method began to decrease in accuracy at a distance of 2.5 to 4 meters, with a total of 17 failures in detecting faces, so that an accuracy rate of 94% was obtained at a distance x where 0<=x<= 2.5 meters, 73% of the total trial run from a distance of x where 0 <= x <= 4 meters, this also does not rule out the possibility that it will have a difference with the quality of the camera used because the quality of the camera used will certainly affect the details of the image captured by the camera.

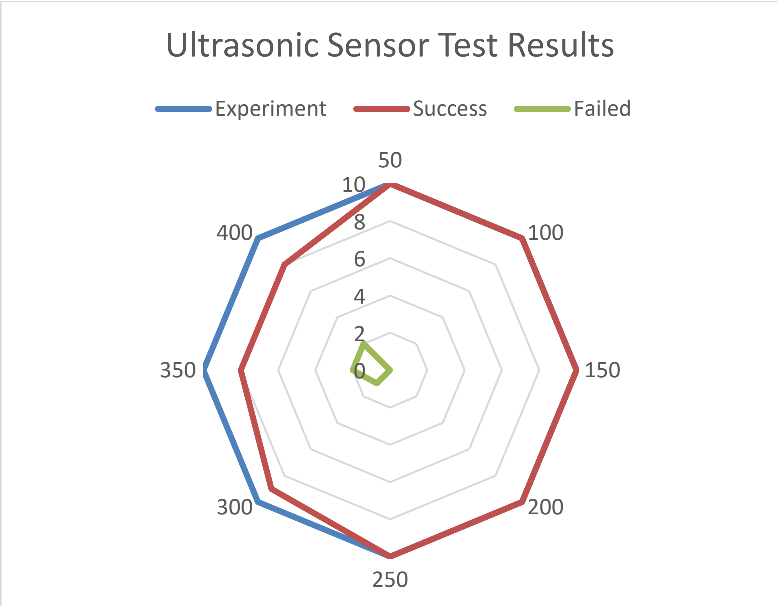


Figure 19. Ultrasonic sensor test result

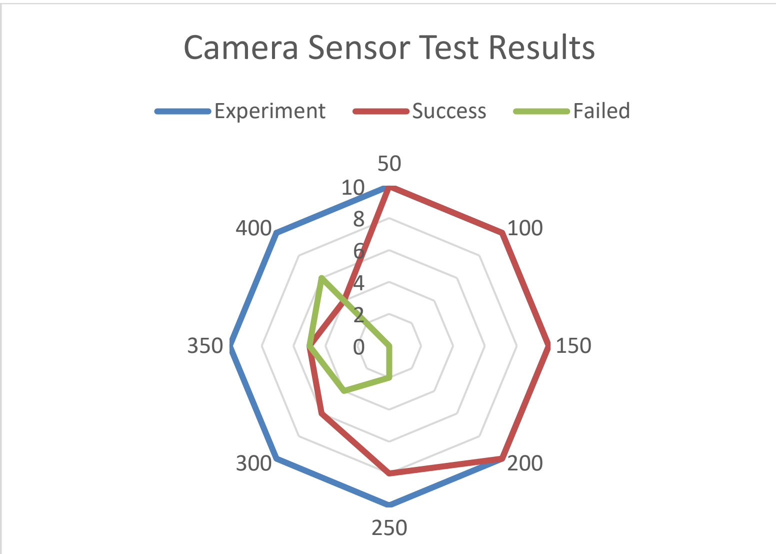


Figure 20. Haar cascade camera test result

4. CONCLUSION

From the research that has been done starting from the initial stages of data collection to testing, it is found that the Haar cascade method gives positive results in detecting facial images, especially in conditions that are in accordance with the test environment described in the results and discussion section, which is proven with a sufficient level of accuracy. Both at a distance of 0 to 2.5 meters with an accuracy value reaching 94% although accuracy begins to decrease at further distances, and this can be tried to be tested using a device that is better than the raspberry pi camera used in this study, if in this study the camera is activated when the ultrasonic sensor detects an obstacle, of course it still has drawbacks when crowded conditions will cause the camera to continue to take pictures and this will have an impact on computational weight on raspberries, for that in future research it needs to be combined with machine learning that can automatically determine when it's time for the camera to process the image and when it's not.

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