Smart hand sanitizer dispenser

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***Abstract*—The main aim of this research is to design a smart hand sanitizer dispenser that dispenses optimum amount of sanitizer based on the palm image processing with enhanced IoT features. The research problem of this project is the hand sanitizer dispenser mostly provided in manual dispenser. This will make the hand sanitizer dispenser to be contaminated. The usage of the hand sanitizer also controlled by the individual behaviors. They may use it very little which will not achieving the purpose of using it to curb the infectious virus. They may also use is too much and it can be wasted. The method used to achieve the objectives of this project is by using the Raspberry Pi B+. The system is implemented by using Haar Cascade Classifier to detects the hand palm and measure the hand by using Euclidean distance and pixels per metrics. The system also consists of monitoring and alert features. The liquid level of hand sanitizer is monitored by using Node-RED. An alert system also constructs to remind the owner to refill the hand sanitizer. Other than that, PIR sensor is used to detect the presents of human in the nearby and give out a message through speaker to remind people using the hand sanitizer.**

***Keywords*— Hand sanitizer dispenser, image processing, IoT, Haar Cascade Classifier, hand palm, Euclidean distance**

I. Introduction

Neonatal death is During the current Covid-19 outbreak, it is crucial for everyone to wear a mask in public areas, keep a social distance minimum 1 meter and always wash hands with soap or hand sanitizer. These practices are an early precaution that can be taken to curb this pandemic. Regardless of private or government sectors, every person is responsible to make sure that the virus is not easily spread in a community.

Commonly, hand sanitizer is provided to the customers or visitors at the front door or administrative counter. Workers are also placed at a certain location in the premises to keep track of the customer or visitor information as a record and dispense the hand sanitizer. This is a good step to help the society from the virus. However, almost all of the hand sanitizer dispensers used at these places are manual-type dispensers.

This way of using the hand sanitizer will lead to waste of resources and it is also increasing the production cost of the business. This is because the hand sanitizer might be used up too fast with the manual hand sanitizer dispenser which will require the responsible personnel of that premise to restock frequently. Though, too little sanitizer applied on hands is not good as it is not achieving the objective to prevent from the infectious virus. Thus, this project is to design and develop the smart hand sanitizer that can automatically dispense the enough sanitizer according to the individual's palm size when reaching out for it.

A compulsory guideline is given from the government for places that will require close and direct contact with people. One of the guidelines is to provide hand sanitizers at the entrance of a place or building. Therefore, it is compulsory for the owner of the places to purchase and provide the sanitizer for the society. Usually, the hand sanitizer dispenser provided is a manual dispenser. So, there will be a direct contact between the dispenser and the user, and the dispenser will be contaminated [1]. Therefore, the main aim for this research is to design a smart hand sanitizer dispenser that dispenses optimum amount of sanitizer based on palm image processing with enhanced IoT features.

The dosage for an alcohol-based hand rubs or hand sanitizer is determined by measuring the efficacy using a model protocol such as EN 1500 which recommended by manufacturer. The volume of the hand rub is effective when it covers the hands and remain wet for sufficient time. World Health Organization (WHO) suggest the contact time for Alcohol-based Hand Rub (ABHR) hand hygiene is 20s to 30s and it is supported by a study that highly effective time is 15s [2]. The researcher mentioned that in order to pass the standard in-vivo efficacy test, the volume recommend is 2x3ml 60% v/v isopropyl alcohol for 60s. However, the minimum volume to meet standard is 3ml and it is unknown whether it is appropriate to meet the WHO requirements of 20s to 30s. The recent work shows that the required time for the hand to dry consume more than 30 for various hand size and the full coverage may be achieved by using smaller volume.

[3] run a series of study to gain a better understanding of the optimal dose of ABHR for use in health care. The volunteers participate are healthcare worker (HCW) from various hospitals. The data obtained is combined from the sites involved. These participators were trained by an infection expert control about the hand hygiene method recommend by WHO. The researcher proposed four components to achieve the aim. The first component is establishing the drying time of the hand rub with different volumes of Deb InstantFoam, 65% ethanol, and 10% n-propanol alcohol in gel, liquid and foam. The next component is evaluating the hand coverage for ABHRs with different volume.

[4] proposed a water level indicator with low voltage consumption and cost that can be use at water reservoir. It is used to monitor the level so that the wastage can be controlled and the shortage of water in the reservoir.

The device keeps the user aware and avoid from the lack of water. The device is made up from as less resource as possible. Conducting wire is use as the water level indicator. There are four levels used to measure the water level in a water tank. When the water filling up the water tank, the LED which is used as the indicator of each level will light up one by one. The third LED indicate that the tank is going to be full.

[5] propose an algorithm for a robust system of hand detection in a vehicle and achieved 20% of the detection accuracy higher than the second best in the Vision for Intelligent Vehicles and Applications (VIVA) challenge. The method proposed by the researchers is Multi Scale Faster Region-based Convolutional Neural Network (MS-FRCNN) as the standard Faster R-CNN is very hard to detect the hand robustly. The features is use to handle the hand detection problems under a challenging condition of digital images. A multiple scale deep feature extraction is introduced in the system. In the implementation, Regional Proposal Network (RPN) are employed with R-CNN in multiple scales to train the hand proposals [5]. The last convolution layer (conv5) is quite large and the information of the features in insufficient to encode as there is more convolutional information outside the ROI region. However, the naïve concatenate of the layers can be solved by applying the weight normalization. It to tune the downstream parameters for each future map tensor by employing a scaling factor of each tensor and scale the output. 1x1 convolution layer is applied to return the same channel size as the Faster-RCNN feature map tensors [5].

In the recent years, advancement of technology has led to an increase in research and development of Internet of things (IoT) devices [6-18]. The CCTV applications normally costly as it uses computer. The researchers proposed a system using raspberry pi with PIR sensor to trigger when there is a presence of people. The IoT application also use to monitor the situations and receive notifications when there is motion detected. The efficiency of the system rapidly increase as amount of error decreases as the system is fully automatic [19].

Raspbian OS was used as the operating system. The hardware use in this system are USB camera, Raspberry Pi, Android device, PIR sensor and Pushetta Application. The methodology of the system is implementing the USB camera to raspberry pi and detect the motion. The motion is detected by using the PIR sensor and the camera triggered only when it detects the motion [19]. The limitation from the implemented system is it only capable to record and send notifications to the owner without early prevention.

[20] proposed an innovative and effective digital video stabilization technique. It utilizes foreground feature in the video to have a consistent and stabilized output. After the object is isolated, the output of traditional representative point matching (RPM) algorithm for stabilization is generated by applying mean filter compensating the difference in the position of the object.

[21] investigate hand surface area (HSA) as a percentage of body surface area (BSA) using physical measurement and digital planimetry and establish the influence of age, gender, body mass index (BMI) for age and ethnicity. The HSA was measured by using a standard physical measurement method and digital planimetry method. The hand become relatively smaller by a factor of approximately 0.08% when child gets older to late childhood as the BMI increased, the hand got relatively smaller.

II. System Implementation

Fig1. shows the overall block diagram of the smart hand sanitizer dispenser. The microprocessor used in this device is Raspberry pi which is used to process the system. There are three inputs and two outputs in the system. The first input is a pi camera which is used as a vision input that is for measuring the palm size. The predetermined amount of hand sanitizer is then selected according to the palm size.

The amount of the hand sanitizer is dispensed according to the rotation of the servo motor which is attached to the nozzle of the container. The second input in this system is an ultrasonic sensor. This sensor is used to measure the hand sanitizer level in the hand sanitizer container by measuring the length between the liquid to the sensor. The data is then shown on Node-RED for monitoring.

The next input is the PIR sensor. This sensor is detecting a motion which when a person passes by the device, a voice alert is given to that person as a reminder to use the hand sanitizer. The voice alert is using a speaker.

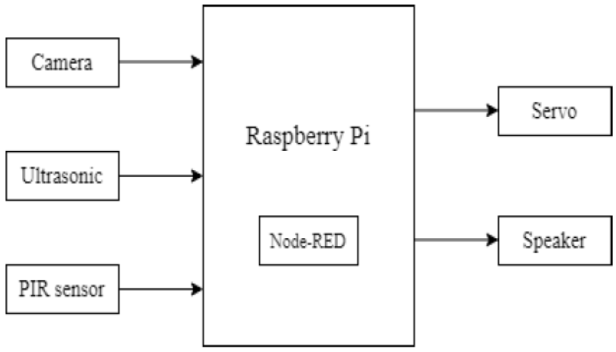

Fig. 1. Overall block diagram of the system

Fig 2. shows the overall connection of the system. In this system, image processing is used to measure the hand palm size. This is achieved by using a pi camera that is connected to the Raspberry pi 3 B+ microprocessor. Then, the device will dispense the hand sanitizer by pressing the nozzle container using a servo motor. The pulse pin of the servo motor is connected to GPIO 27. The angle of rotation of the servo is sent through this pin.

In order to measure the actual length of the hand palm, the pixels per metric is used. A reference object needs to be used to find the pixels per metric of an object in the image. The pixels per metric is defined as pixels per metric = object width/actual width. The object width is obtained by using Euclidean function.

The python code usually programs using the duty cycle of the servo to rotate it to the desired angle. Therefore, the ratio of the duty cycle and angle can be used to program the code conveniently. The minimum duty cycle of the servo is 2% while the maximum is 12%. The servo used in this system can only be rotated up to 180°. Therefore, the ratio is calculated as the Equation 1.

$$\frac{Duty\ cycle - 2}{12 - 2} = \frac{\theta}{180}$$

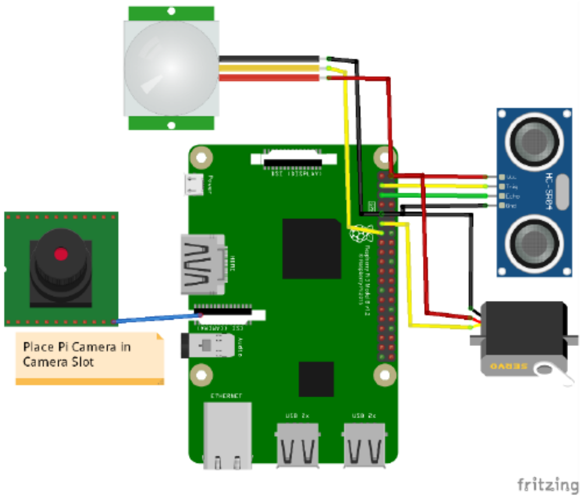

Fig. 2. Overall system connection of the system

Generally, the ultrasonic sensor is used to measure distance of an object. In this system, it is used to measure the hand sanitizer level by measuring the length between the sensor and the hand sanitizer. The echo pin is connected to GPIO 2 and the trigger pin is connected to GPIO 5. The PIR sensor in this system is used to detect humans in terms of motion. If the sensor detects motion, it will generate a message through voice using a speaker to forewarn the individuals to use the hand sanitizer. The output pin of the PIR sensor is connected to GPIO 17.

III. Working Principle

There are several modifications made in the flowchart. As the palm size is classified into small, medium and large size, the amount of hand sanitizer is also classified into three volumes which is 3ml, 4ml and 5ml respectively. Other than that, the message of "Please Refill!" is generated when the level of hand sanitizer is below than 25%, the message of "Very Low!" is generated below 15% and the message of "Shutting down!" will be generated if the hand sanitizer level is below than 5%.

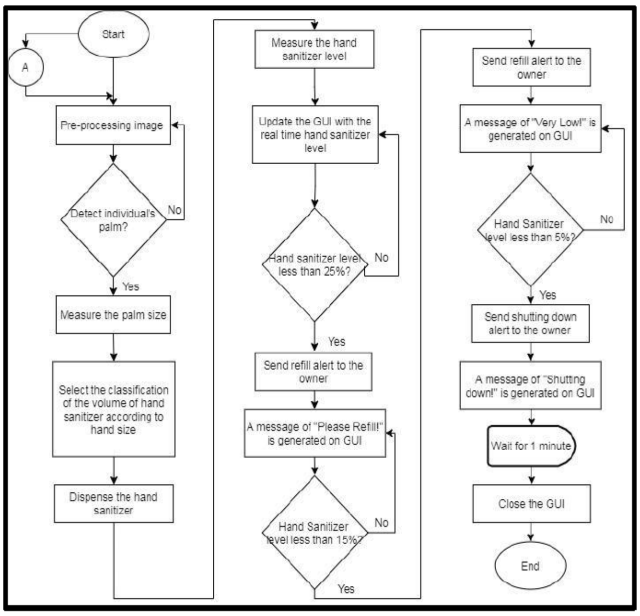

Fig. 3. Flowchart

In order to dispense the optimum value of the hand sanitizer following the size of the hand palm, the palm size is classified into three categories. This classification is obtained from the previous study which mentioned that small hand is less than 375 cm^2, medium-sized hand palm is in between 376 to 424 cm^2. and the large-sized is more than 425 cm^2. The amount that is mentioned in the previous study for each category are 2.5ml, 2.5ml and 3ml respectively which the value is enough to reduce the bacteria.

Fig 4. shows the results of hand palm detection and the length measurement of the palm hand region. As observed, the system is not detected the hand if a person put out the left-hand palm and dorsum. The length is measure by detecting the most outer counter each side and measure it with pixels per metric ratio.

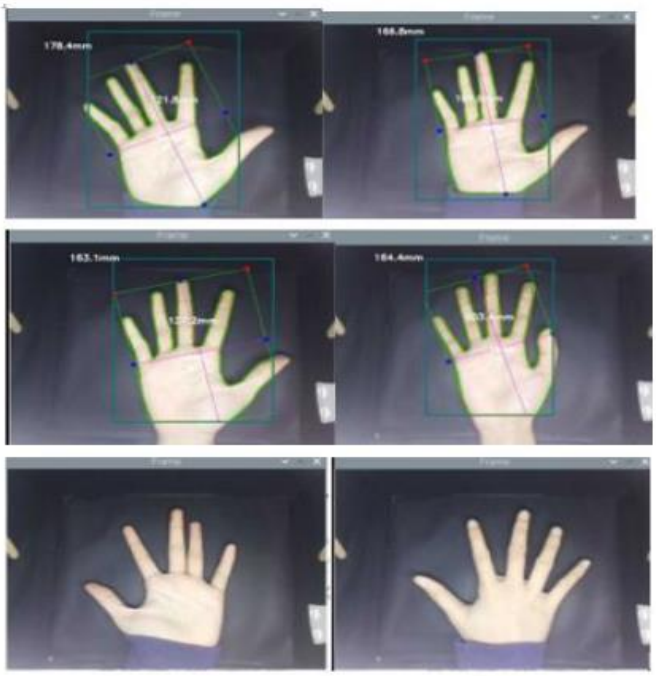

Fig. 4. The results of hand palm detection and area measurement

The Fig 5. shows the prototype of the smart hand sanitizer dispenser system. the camera is attached at the top of the prototype to get the whole picture of hand palm. The Raspberry pi is put at the top as the camera cable is short. Other than that, on top of the frame, there are also PIR sensor that will detect the presence of human. It is put up at the top of the frame to have a bigger region in detecting human.

Inside the frame, there is the hand sanitizer dispenser. The ultrasonic sensor is attached at the top of the container facing downward to measure the distance of the hand sanitizer and the sensor. The nozzle of the container is pump with the help of servo motor. The servo motor is attached at the side of the container. As observed, there are also speaker attached to the Raspberry pi. This speaker is used to give an alert message to the person nearby so that they use the hand sanitizer.

The lighting is needed as the length measurement is done by using contour. The contour is applied to the detected hand palm frame and the length is measured.

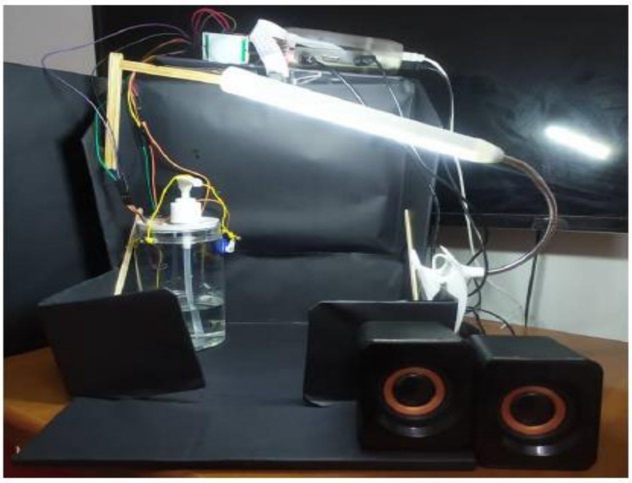

Fig. 5. The overall hardware of the system

Fig. 6 shows the GUI of the system. This GUI is related to the monitoring of hand sanitizer level. The data is updated every second as the hand sanitizer can be monitored in real time.

Fig. 6. The GUI of the system

Fig 7. is showing the alert message of the smart hand sanitizer dispenser generated when the hand sanitizer level reach at certain value. The message is generated to give a reminder to the user for the refill purposes. This also prevent the device to broke if the device is still operated with empty hand sanitizer.

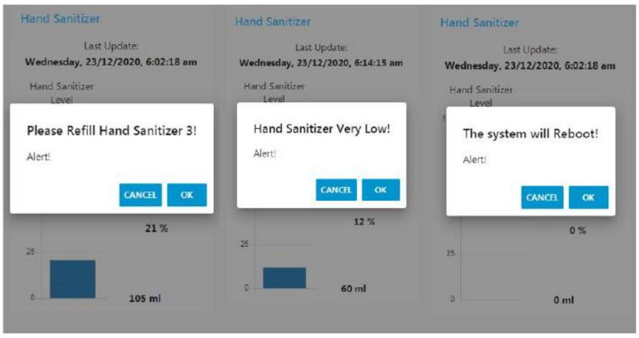

Fig. 7. The alert message of the GUI

IV. Testing of the Proposed Design

A) *Hand sanitizer level test*

These tests are done to determine the accuracy of the hand sanitizer. The input of the test is the distance measured by the ultrasonic sensor and the output is the hand sanitizer level percentage. Table I. shows the hand sanitizer level test. The data in the Table I is the distance measured by the hand sanitizer and the percentage of the hand sanitizer in the container. As mentioned in the previous chapter, the hand sanitizer level is calculated by using the distance of the hand sanitizer to the sensor itself.

TABLE I. THE HAND SANITIZER LEVEL TEST

Ultrasonic readings (cm)	Hand Sanitizer Percentage (%)
0	0
11.33	12
10.37	21
7.19	51
6.35	59
2.21	98

The results show that when the distance is decreasing, the hand sanitizer level percentage will be increases. This is because the nearer the liquid to the sensor, the more the hand sanitizer liquid is. However, the usage of this device is obviously in the pattern of increasing of the distance as the hand sanitizer is being used.

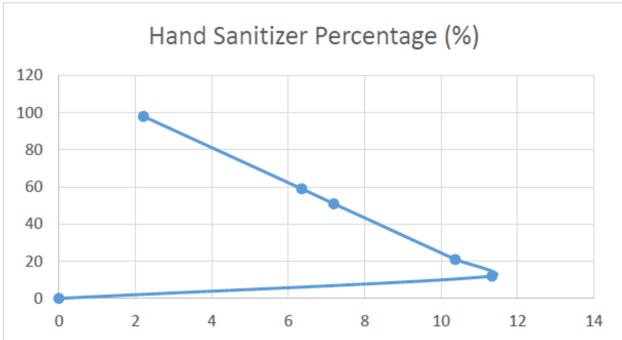

Fig. 8. Distance and the percentage of the hand sanitizer

B) *Accuracy of volume of hand sanitizer dispense*

The volume of the hand sanitizer dispenses by pressing the nozzle of the container using the servo motor. The total pump of the nozzle is giving the total amount of the hand sanitizer for certain hand size range. The volume of the hand sanitizer is measured by using syringe to obtain the dispense volume.

TABLE II. THE ACCURACY TEST OF VOLUME OF HAND SANITIZER DISPENSE

Ultrasonic readings (cm)	Hand Sanitizer Percentage (%)	Volume dispense (ml)
Small	4	2.4
Medium	5	3
Large	6	3.6

Fig 9. shows the graph of the hand sanitizer being dispense by using the servo motor and the total number of pumps. This total number of pumps is assigned as that to make sure that the

hand sanitizer is sufficient to be used by the user. As observed, as the total number of pump increases, the volume of the hand sanitizer also increases.

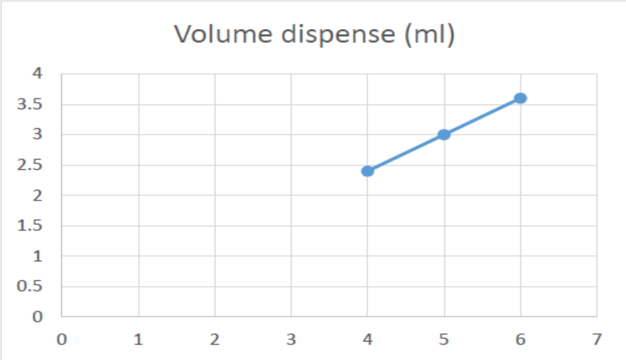

Fig. 9. The graph of the total number pump to the volume dispense.

Table III is showing the volume of hand sanitizer measured by using the system and manual measurement by using the scaled container. As observed, there is slightly difference at between the two data. The highest difference between the two data is 5ml. therefore the accuracy of this hand sanitizer monitoring level is 98.1%.

TABLE III. THE DIFFERENCE BETWEEN THE VOLUME MEASURED AND THE ACTUAL VOLUME

Volume measured	Actual volume
0	0
60	60
255	260
295	300
490	490

As mentioned before, the length of the hand palm measure is slightly differed to the previous study. The system is measuring the length by determine the outer area of the contour and measure the length in the rectangle box. The actual hand size of the tested person is 134.75cm2 which measure by using the standard equation, height times with the width.

V. CONCLUSION

The basic idea of the system is to control the cost of purchasing the hand sanitizer. As the amount of hand sanitizer dispense is controlled according to the hand size, the hand sanitizer may be used up in a slow rate. Therefore, the user can save the costing in order to help curbing this infectious virus. This system is also low in cost which it can be purchased by the targeting market which is SMEs. The hand sanitizer is dispensed by using the servo motor and the PIR sensor is used to detects presence of human and give out an alert to the nearest person so that they remember to use the hand sanitizer. An alert system is also generated to remind the owner for the hand sanitizer refill.

In order to improve the performance of this system, the Haar cascade classifier must be trained to detects both hand palm. Throughout the project, this classifier for the hand palm is hardly find. However, in order to train the cascade for the detection, a high specification of processor is needed to do so as there are many negative and positive images is needed to classify the object desired.

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