Vol. 06, No. 2 (2024) 885-896, doi: 10.24874/PES06.02A.015

Proceedings on Engineering Sciences

www.pesjournal.net

INA: INTELLIGENT NURSING ASSISTANT ROBOT FOR QUARANTINE MANAGEMENT UTILIZING HAAR CASCADE ALGORITHM AND CAGEBOT MATERIALS

Helen Grace Gonzales [1]

Received 29.07.2023.
Received in revised form 29.11.2023.
Accepted 15.12.2023.
UDC – 004.85

Keywords:

Deep Learning Haar Cascade, Mobile Manipulation System, Nursing Assistant Robot, Data Acquisition, Coronavirus

A B S T R A C T

The Intelligent Nursing Assistant Robot (INA) emerged as an innovative solution with COVID straining the healthcare systems and over 180 million cases globally by April 2021. INA protects overworked and exposed staff by remotely monitoring patients in quarantine. This robot boasts features like a thermal camera for precise temperature readings and a high-definition camera for visual checks. Facial recognition aids in patient identification, while its mobile control via an Android app and Pixy camera with Arduino connection offers flexibility. Built with durable Cagebot materials, INA provides a safe and versatile tool for overwhelmed healthcare professionals during this critical time.

© 2024 Published by Faculty of Engineering

1. INTRODUCTION

Coronavirus, caused by a newly discovered virus, leads to illness in many infected individuals, necessitating treatment. Vaccines are available as of April 2021, but ongoing trials explore potential treatments. The World Health Organization's main goals include reducing human-to-human transmission, preventing secondary infections, and caring for patients. Robotics, AI, and other technologies are crucial in combating the virus, enforcing social distancing, and developing innovative tools. As of June 2021, there are over 180 million infections and 3.9 million deaths worldwide. The pandemic affects global health and economies.

Social distancing is currently the primary preventive measure. Robotics, AI, and new technologies, including drones and disinfection robots, play a significant role in pandemic control. This study focuses on using Raspberry Pi as the robot's brain, utilizing Wi-Fi for communication, and a mobile app for user control. The hardware and software details, including the use of the Haar Cascade algorithm for facial recognition and temperature scanning, will be thoroughly explained in subsequent sections. Results and discussion will cover MIT App creation, mobile control, facial recognition, and temperature scanning. Although integrating all components is a goal, time constraints may limit full implementation, leaving room for future study.

[1] Corresponding author: Helen Grace Gonzales
Email: helengrace.gonzales@ustp.edu.ph

2. LITERATURE REVIEW

2.1 Covid-19

The global impact of Covid-19 has drastically affected health and safety measures, particularly within the hospitality sector. Amidst this scenario, the integration of robotics presents promising avenues to streamline quarantine protocols and maintain daily operations for travelers, both domestically and internationally.

2.2 Robots during Pandemic

Offered the nature increasingly transmittable brand-new corona infection is very challenging for clinical personnel to respond directly to guests or potential situations without defense, respirators, goggles, gloves or gowns that remain in short supply in times of emergency. The requirement to sanitize spaces with possible contamination is incredibly important to avoid the greatest feasible spread, which is why it was needed to use a mobile robot capable of cleansing an area as well as thus avoid contamination. The UV-Disinfection robot (Figure 1) has actually been extremely valuable considering the start of the break out of the pandemic (Cardona et al., 2020). They began to damage infections, also currently the systems run in greater than 40 countries, including the USA as well as nations in Asia and also Europe.

Figure 1. UV-Disinfecting Robot

2.3 Discussion on Face Recognition

Face recognition technique is used in many applications such as surveillance systems, medical field, security, robot navigation, etc. Because of this technique, a big improvement in the area of face recognition has been seen. The importance of facial recognition comes to more importance during this pandemic situation, for attendance marking people monitoring, in health care, social distancing, etc. Today, many facial recognition algorithms are available but the execution of these algorithms demands many factors and which gives out poor real-time utilization. The most commonly used algorithms for face recognition are R-CNN, Fast R-CNN, and YOLO (Menon et al., 2021).

2.4 Discussion on Face Recognition

One of the machine learning-based approach is called Haar Cascade Positive images are the images that we want our classifier to identify. Negative Images do not contain the object we want to detect.

In the Viola-Jones algorithm, the instructions are made up of Haar signs, which are a set of rectangular kernels as in Figure 2. In the earlier version of the Viola-Jones algorithm, only signs without rotations were used, and in order to calculate the value of the result, the sum of the pixel intensity of one subregion was subtracted from the sum of pixel intensity of another subregion shown in Figure 3 are the Haar Features without rotation.

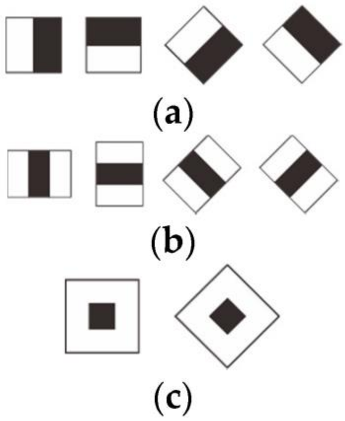


Figure 2. Types of Haar Features.

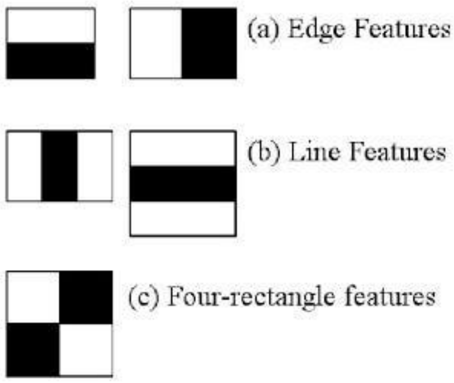
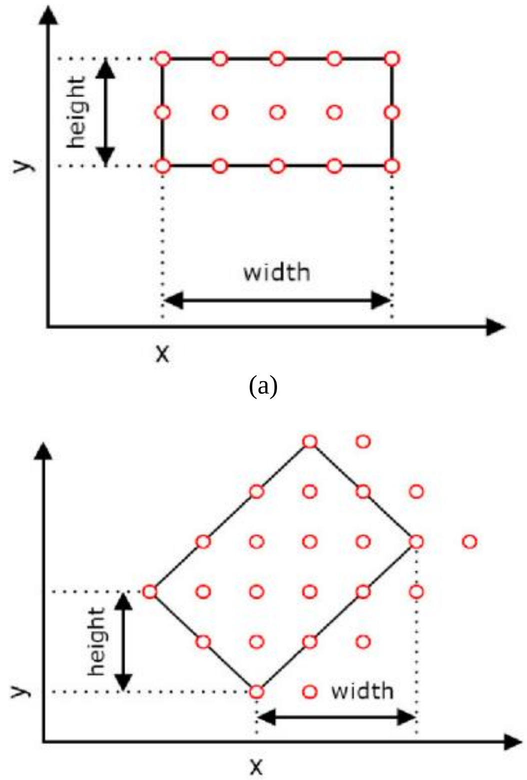


Figure 3. Haar Features without rotation

In the development phase of the method, signs with a rotation angle of 45 degrees and asymmetric configurations were proposed and in Figure 4 & 5 are the features and tilted haar defined by IppiRect Structure.

$$feature_1 = \sum_{i \in I=\{1,\dots,N\}}^{\infty} \omega_i \cdot RecSum(r_i) \quad (1)$$

The formula (1) means it was proposed to assign a certain weight to each subregion and calculate the corresponding values as a weighted sum of pixels of different types of regions. (where the weights (Wi), the rectangles, and N are arbitrarily chosen.)



(a)

(b)

Figure 4. (a) Haar feature & (b) Tilted Haar defined by IppiRect Structure

To decide the class in each cascade, there is a sum of the quantities of the weak classifiers of this cascade. Each weak classifier in formula (2) gives two quantities, depending upon whether the value of the attribute belonging to this classifier is greater or less than a given threshold (Harmouch, 2020),

$$\sum_{i=1}^{k}(\omega_1 \cdot \sum_{u=i+R_1y}^{R_1y+R_1height-1} \sum_{u=j+R_1y}^{R_1y+R_1width-1} A_{uv}) < norm(i,j) \cdot threshold(t) \quad (2)$$

where w_1 is a feature weight, norm (i, j) is the norm factor (standard deviation on the rectangle containing all features), threshold(t) is a parameter of the classifier.

2.5 Discussion: Temperature Scanning

According to U.S. National Library of Medicine, Mean-body temperature (MBT) is the mass-weighted average temperature of body tissues. Core temperature is easy to measure, but direct measurement of peripheral tissue temperature is painful, risky, and requires complex calculations. Direct measurement of peripheral tissue temperature can be accomplished by insertion of sufficient needle thermocouples combined with relatively complex calculations. Alternatively, MBT can be estimated from core and mean skin temperatures with a formula proposed by Burton in 1935: MBT = 0.64. TCore + 0.36. TSkin. This formula remains widely used, but not been validated in the perioperative period and seems unlikely to remain accurate in dynamic perioperative conditions such as cardiopulmonary bypass. We thus tested the hypothesis that MBT, as estimated with Burton's formula, poorly estimates measured MBT at a temperature range between 18 and 36.5° C.

In 1935, Burton cleverly proposed that mean-body temperature could be calculated from a formula: MBT = * TCore + (1-) * TSkin. The general form of the equation was based on the logic that core tissues are relatively homogeneous whereas tissue temperature in the peripheral decreases parabolically from core temperature to skin temperature. The value of, the coefficient describing the contribution of core temperature to mean-body temperature, was then estimated by simultaneously measuring the change in body heat content (in a calorimeter), core temperature, and mean-skin temperature. The resulting value of the coefficient alpha was 0.64, thus giving the formula: MBT = 0.64 * TCore + 0.36 * TSkin

3. METHODOLOGY AND SYSTEM DESIGN

3.1. System Design

The system, illustrated in Figure 5, comprises various components, including a mobile application created with MIT APP linked to a Raspberry Pi, connected to a 7-inch LCD HDMI monitor for monitoring. The Raspberry Pi receives inputs from peripherals, a Logitech web camera for facial recognition, and a Pimoroni mlx90640 for temperature scanning. The mobile application wirelessly sends commands to the Raspberry Pi. The user can freely use the mobile app (Figure 8) to control the robot, capture images of the guest, get the temperature and then upload the data to the database. The mobile control is directly connected to Arduino.

The facial recognition schematic as in Figure 7, utilizing the Haar Cascade algorithm, outputs commands for mobile control, directing an Arduino Uno connected to a Pixy camera for robot guidance. The system framework as in Figure 5 begins with mobile control through the Android App, enabling users to control the robot, capture guest images, obtain temperatures, and upload data to the database.

Mobile control connects directly to Arduino, assisting the robot's movement in quarantine areas while maintaining distance from healthcare workers. Facial recognition, using a Logitech camera connected to the

Raspberry Pi, identifies guests based on stored information. The temperature scanning module, employing Pimoroni's MLX90640 camera, detects and displays temperatures on the monitor. Data is then stored in the Raspberry Pi memory.

Figure 6 depicts the entire processing and peripherals, highlighting the interconnected components, including the Arduino. The system transmits data from the Raspberry Pi to the mobile app through Wi-Fi. The Arduino, equipped with a Pixy camera for line tracking, controls DC motors via an L298N motor driver as in Figure 9. Power is supplied to the Raspberry Pi through a DC-DC buck converter, while the LCD monitor is connected to a separate power source.

The first step will be the Android app control for the mobile control by the health workers or quarantine service personnel. Movement of the mobile robot will be Start, Stop, Forward, Backward, Left, Right, and so on. During the quarantine services, people under quarantine stay in the rooms for 14 days or more or at least 21 days. Before they can enter the said facility, they will be subjected for some questions and will add in the database by the personnel, to be able for the robot to identify the person during facial recognition and temperature scanning.

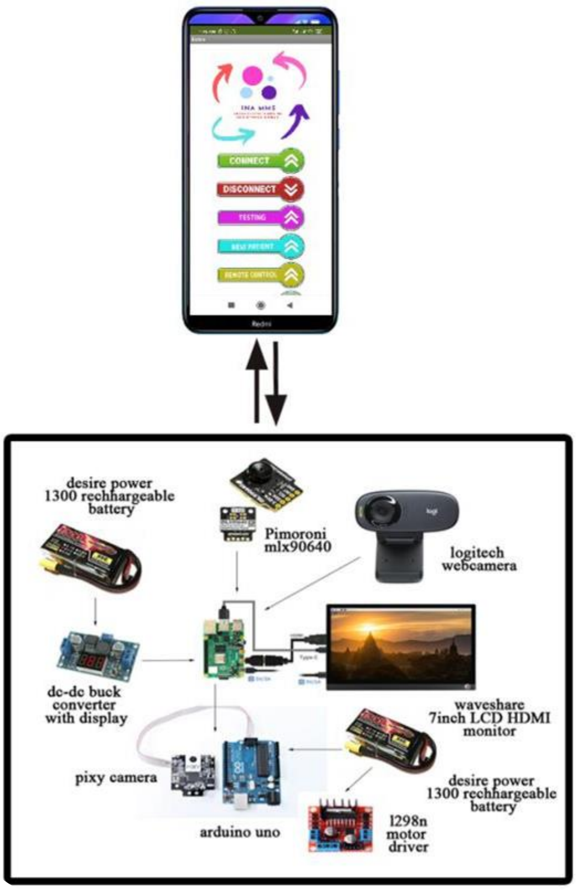


Figure 5. System Design of INA.

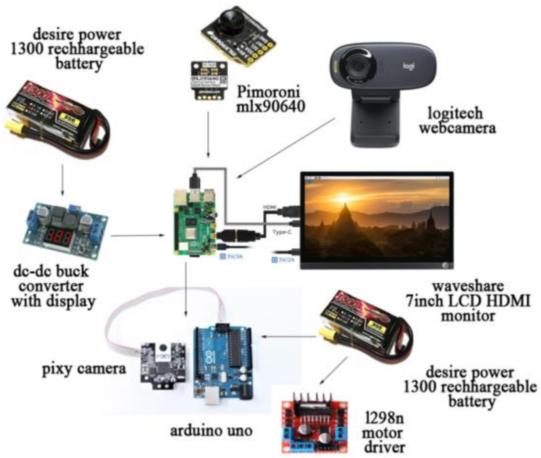


Figure 6. Entire peripherals and interconnected components

3.2. Mobile Control

Start, Stop, Forward, Backward, Left, Right - these are the controls under the Android App as in Figure 8. These are very basic in Robotics. The arduino is connected to Raspberry pi which sends signal to the Arduino for the motor control that is connected to the Motor Driver LN298N. Next, the Pixy camera helps in to facilitate the Robot to be able to follow the instruction, although this component comes handy during autonomous control, this is not anymore part of this research, the autonomous part should come next when time allows.

3.3. Facial Recognition

The facial recognition setup has been completed with the use of Haar-cascade. First, the person to be quarantine should be able to fill-up a form with the information needed and lastly the personnel must be able to take a photo at least 5-7 pictures. During the scheduled daily check, the person must face the camera to be recognized. The raspberry pi shall process the face captured.

3.4. Temperature Scanning

After the facial recognition, the robot will scan the temperature of the quarantined and will display the temperature in the HDMI display in front of the robot. Component used for Thermal scanning is the Pimoroni MLX90640. The robot will automatically detect the temperature of the person after it processes the Facial recognition and has recognized the person. The MLX90640 IR thermal camera (Xu, 2020) can display the relative temperature and shape of the person as long as you put them in front of the IR thermal camera. IR thermal camera connects with Raspberry Pi 4 var I2C interface, after reading the data from the camera, raspberry pi 4 would process these data and convert them to numbers of pixels and finally displayed as a thermal image on the Raspberry Pi display.

3.5. Data Acquisition

The robot will then save the information into Raspberry pi. This process is still limited due to time constraint and due to complication of the process and limited resources. This part contains significant programming details for the Mobile app and will send data from app to its database. Although this is seemingly complicated, this will be further explained for the continuation of this study. This will be one of the limitations of the study and shall be considered a continuation study for the researcher.

4. RESULTS AND DISCUSSION

Actual Robot with main components: Mobile Base, Sensors & Peripherals, Controllers

Facial recognition test of two people using camera.

Sample Training of Pimoroni's MLX90640

Android app home screen with Connect, Disconnect, Testing, New Patient, Remote Control, Autonomous Buttons

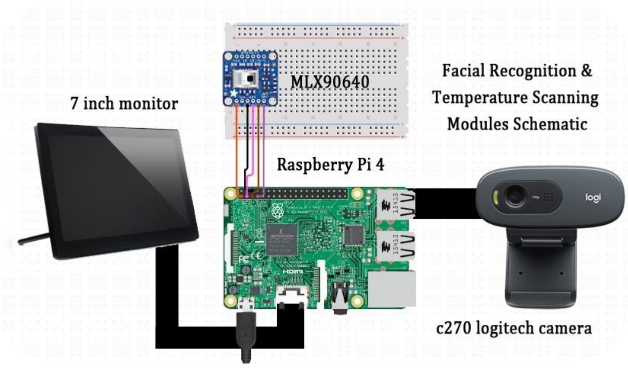


Figure 7. Facial Recognition & Temperature Scanning Modules Schematic

4.1. Initial Results

INA is designed with a simple structure with a little hollow top to carry the necessary components. Figure 10 shows the actual initial model and the Figure 11, the cagebot actual model. It is designed in that way for minimalist approach. It is a four-wheeled vehicle the dimension of the AGV is, 105cm * 13cm * 27cm. The robot's body is designed with a straight front part, wherein the front part can be fixed with the pixy camera for line monitoring purposes. The 3 basic parts of the Robot is the Mobile Base, Frame, and the Peripherals. The Mobile base is composed of the metallic material and also the other composition of the base with the Wheels.

The second model is composed of cagebot materials. INA can be remotely controlled and can also use the Telemonitoring function easily since there is an installed monitor. The Robot can also be autonomous as well, following a certain pattern and symbols using Pixy Camera. Pixy is capable of tracking hundreds of objects simultaneously and provides the data and can be connected directly to arduino. The algorithm used for Facial recognition (Haar Cascade) that is a machine learning based approach in which a cascade function being trained from a lot of positive and negative images. Initially, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier (Guardian News and Media, 2016).

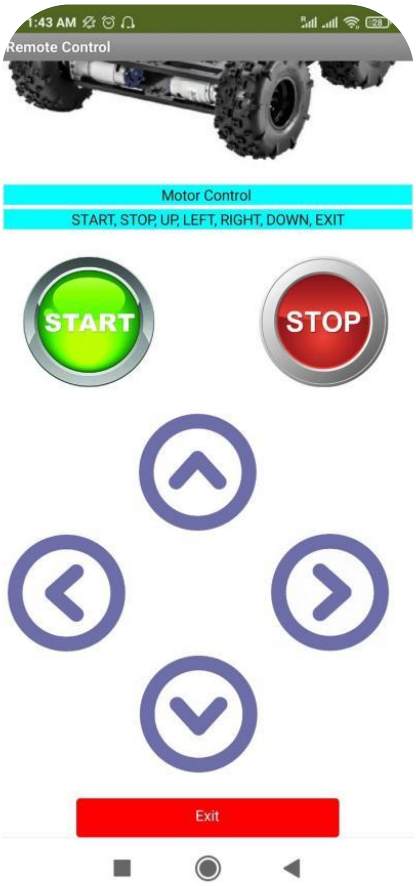


Figure 8. Android App with Start, Stop, Forward, Backward, Left, Right

First phase (Figure 12) before the recognition of the images is the Facial capture program in which the robot captures the image of the client first and save the image files to the memory. The next phase is the running of the program for the recognition. The need to create the data and add the name of the client is very relevant and must be done simultaneously while capturing the image of the client. Moreover, the efficacy of this algorithm is so high and it is even the base of most Facial Recognition devices in the market. The use of this Facial Recognition algorithm in this research is very relevant.

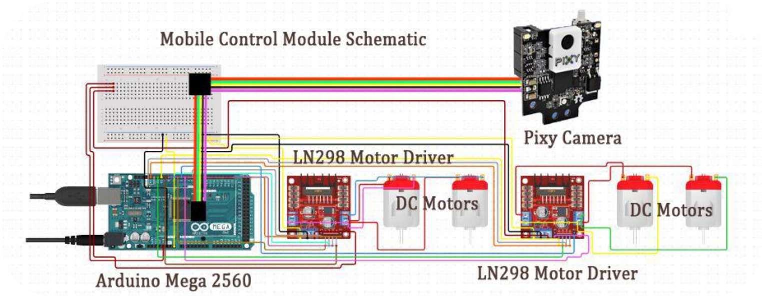


Figure 9. Mobile Control Module Schematic

The next phase (Figure 13) is the usage of MLX90640 IR thermal camera that can basically display the relative temperature and shape of the objects as long as you put them in front of the IR thermal camera (Xu, 2020) as shown in Figure 15. IR thermal camera connects with Raspberry Pi 4 var I2C interface, after reading the data from the camera, raspberry pi 4 has processed these data and converted them to numbers of pixels and finally displayed as a thermal image on the Raspberry Pi display.

The next phase of the research is creation the App using the MIT App Inventor Blocks Editor in which the blocks were program and assembled which specify how the pieces and components fit together. Easily the app appears in our phone step-by-step as the components we added and programmed. The app has been packaged and can now be reproduced as stand-alone ready to be installed. Currently, the researcher created 4 pages for the app. As shown in Figure 14a, the first page is the Start Page where the medical worker can choose the activities they want to do for the robot. Connect the robot from the app, Disconnect, Testing, New Patient/Client, Remote Control for the Mobility of the Robot. It is also one of the limitations as of testing since the Autonomous function is still very difficult and needs relevant time to complete.

Figure 10. Initial designs of INA using metal and steel

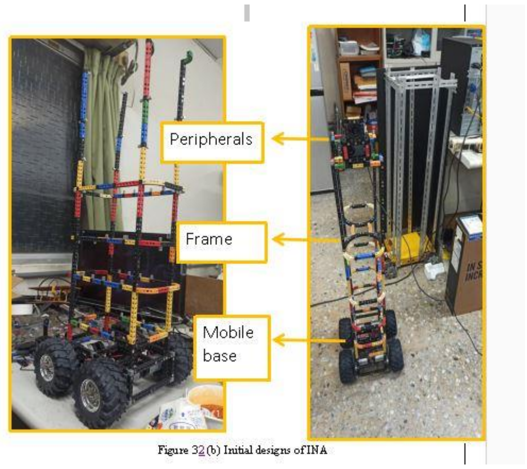


Figure 11. Initial designs of INA using cagebot blocks

Figure 12. Facial Recognition Testing for 2 people using Haar Cascade

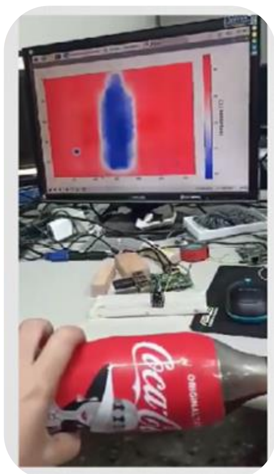


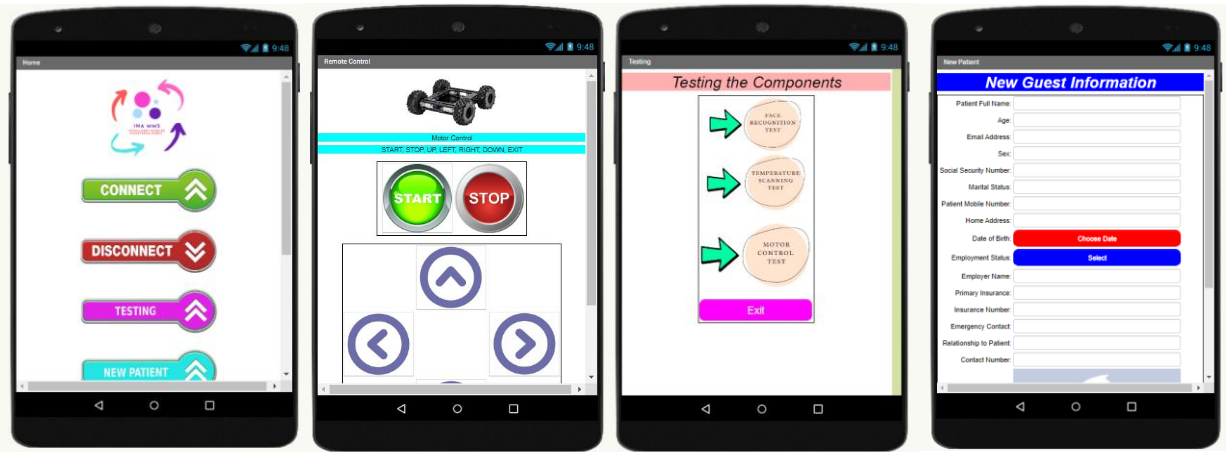
Figure 13. Temperature Scanning using a bottle of cold coke

The second page is the Remote-control function for the robot. Third page is the adding of the database, below the information chart is the adding of the image of the client shown in Figure 14b. The last page would be the testing phase. It is relevant to note that the app is still on its continuing as it is very complex to integrate all the function, components and all the modules involve for the conception of this project. It may however noteworthy that it can be accessed to anyone who wants to view and share their ideas on it.

4.2. Final Results

Over all result for this research, the robot shown in Figure 16 can be controlled using Mobile App, which is INA App created using MIT App Inventor. INA has a 7inch monitor shown in Figure 18 for the screen and program of the Facial Recognition (Figure 17) and Temperature Scanning for the clients and users to see. As of the moment, there is a need to update and methodically program the Application so it can proceed with capturing the images and taking the temperature, which is beyond the researcher scope. It will be added in the limitation and can be continued for future researchers, which is to compile all the functions in the robot.

The use of cagebot blocks can be a good advantage at this point, for easy transportation of the robot. As we all know, Covid has still been lurking around all over the world and easy transportation of this helpful robots is very good especially in the quarantine areas and hospitals.



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

Figure 14 (a, b, c, d). INA App using MIT App Inventor, first few pages

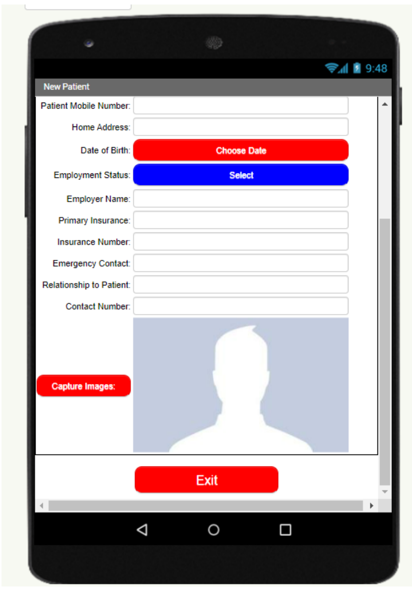


Figure 15. INA App adding the image of the client

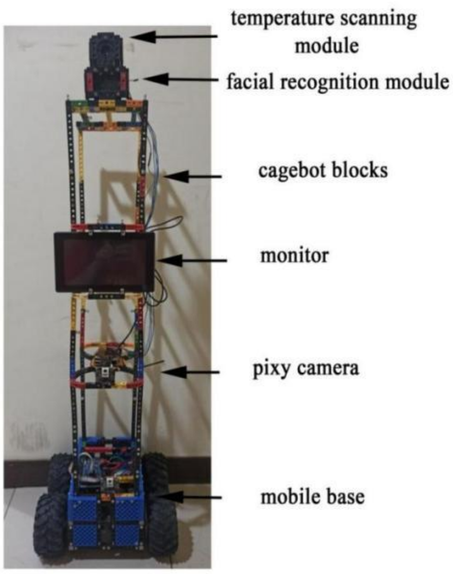


Figure 16. Final overall design of INA using cagebot blocks

The facial recognition function shown in Figure 19 has been tested to almost 10 individuals and has since been accurate for recognizing faces of individuals and identifying them, individually or two (2) to three (3) persons. One of the problems encountered for this part of the research is the integration of the facial recognition with the other modules connected to the Raspberry Pi and as well as the Arduino. The temperature scanning function shown in Figure 20 can provide values of temperature for a person facing the robot.

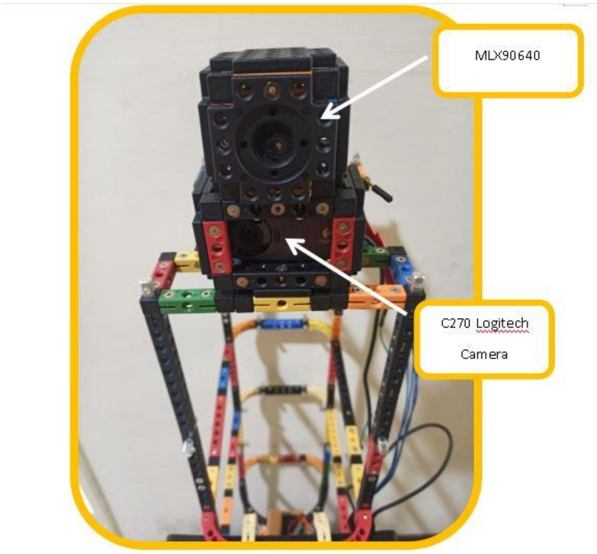


Figure 17. Final overall design of INA the head part

Figure 18. Attached are the Monitor and the pixy camera

Figure 19. Facial Recognition Testing

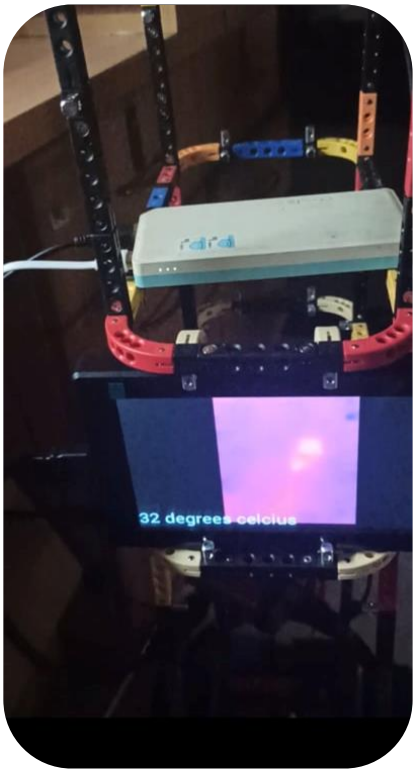


Figure 20. Temperature Scanning Testing

5. EXPERIMENT & DATA ANALYSIS

Engaging in face recognition research presents a formidable and often frustrating endeavor. Amidst the ubiquity of available data and its ease of accessibility from various sources, crafting a reliable dataset remains an intricate task. The seemingly 'random' datasets employed by researchers can also introduce complexities and ambiguities. Data collection must adhere to a set of stringent criteria to ensure its efficacy and relevance (The British Machine Vision Association). Representative of the target population, the data's structure should facilitate comprehensive testing under diverse acquisition conditions. Sufficient data volume is crucial, enabling differentiation between development and testing datasets.

Over an extended time, span, data acquisition should capture the natural variations in subjects' facial appearances. Moreover, the chosen subjects should be readily available for future tests as the research unfolds. Ultimately, the open availability of data fosters result comparison among researchers. In the preliminary experiment, three healthy male subjects participated, maintaining a minimum distance of 1.5 meters from the INA Robot. Subjects assumed stationary postures during data collection. Utilizing the Build Dataset Module program on Raspberry Pi, subject images were captured, as depicted in Figure 21.

Figure 21. An example of the images used for the tests

The results can be shown in the table 1 with the subjects indicated and the test results also (Figure 22). The reader can eventually notice that all the tests were successful and that from the dataset taken, all of the subjects were recognized by the device.

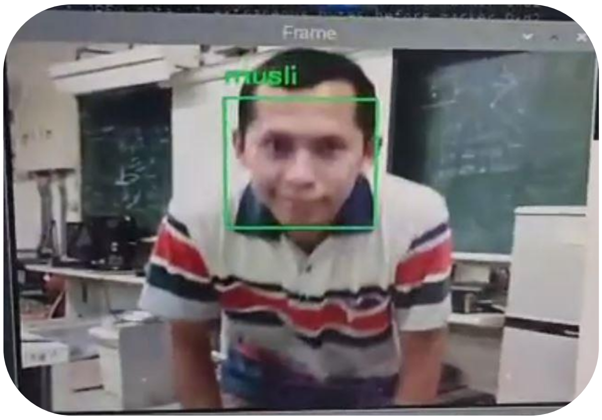


Figure 22. Sample Test Result of the Image Capture

Table 1. Results of the Facial Recognition Testing for 1 set of samples

Subject	Test 1	Test 2	Test 3
1	Recognized	Recognized	Recognized
2	Recognized	Recognized	Recognized
3	Recognized	Recognized	Recognized

One of the problems encountered in this research is that the requirements are inconsistent and the structured set of data is not representative of the real-world population of faces; with data provided by others it is rarely possible to acquire new samples of the faces due to the recent situation and also the application of this project is quite risky.

When acquiring data over a lengthy period of time is also a problem since the author is very limited with regards to time. According to the British Machine Vision Association, a further problem in acquiring a set of data is that it is difficult to have a structured set of lighting conditions. It is easy to use photographic techniques to get good lighting on a subject but it is almost impossible to keep condition consistent throughout the test.

Another difficulty appeared as the methodology moves from the laboratory to the researchers place as the face databases in most citing have been specifically designed only for ladies and Filipino students. This is obviously not representative of most, populations to be recognized. If the system is to be used world-wide then ignoring faces from different, cultures could also cause problems. The approach should be designed according to some conditions such that the system should be trained in a way that many instances of each subject must be captured, also varying expressions and lighting conditions in a consistent way. The aim is to achieve recognition within that range of conditions trained.

The researcher has discussed the screening of face recognition system. It has been shown that a system that functions well with the limited types of data or data that have been thoroughly structured may not necessarily execute as well under different screening programs. The research field of face recognition has gotten to a factor where evidently great recognition outcomes can be attained. The next phase is to investigate more methodically how the reaction differs when target, cues as well as distractors are acquired in a differing variety of conditions (Figure 24).

Figure 23. Dataset for this research includes 6 Filipina ladies with the same setting and location in the University dormitory with the results in Table 2.

Table 2. Results of the Facial Recognition Testing for second set of samples (Figure 23)

Subjects	INA- Skin Temperature (IST)	Skin Device Temperature (SDT)	Ambient Temperature (AT)	Body Temperature (BT)
1	33.3	36.1	26.1	36.1
2	32.9	36.3	26.3	36.8
3	33.4	36.4	27.1	36.0
4	32.7	36.0	26.5	36.47
5	32.9	36.2	26.5	36.8
6	33.0	36.3	26.5	36.1
7	32.8	36.1	26.5	36.9

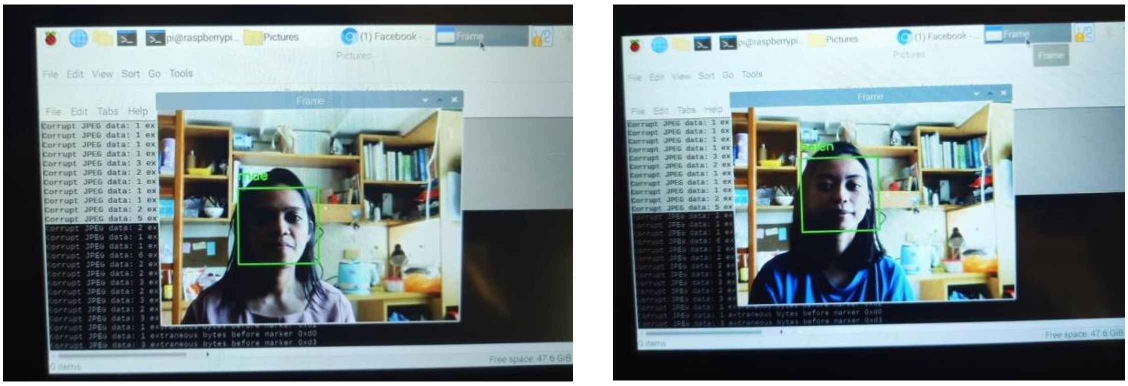


Figure 24. (a, b) Some Random Rejected Images with wrong recognition of samples

At neutral (24–27°C) ambient temperatures, with a core temperature of about 37°C and a skin temperature of about 34°C, the human core temperature is mainly controlled through alterations in skin blood flow and less so by changes in metabolism or evaporative heat loss (cf. Brooks et al., 1997).

Table 3. Comparison of Different Methods on Taking Temperature scanning

Subject	Test 1	Test 2	Test 3
1	Recognized	Recognized	Recognized
2	Recognized	Recognized	Recognized
3	Recognized	Rejected	Recognized
4	Recognized	Recognized	Recognized
5	Recognized	Recognized	Recognized
6	Recognized	Recognized	Rejected

Provided in the table 3 below is the data collected from seven (7) healthy subjects living under the same condition. They have used the same Devices and have tested on the same time. It must be noted that during the testing the ambient temperature has varied which was checked through an app in the mobile. The Body temperature (BT) was checked through digital thermometer. The Skin Device Temperature (SDT) was checked through the sophisticated device from the University and the INA-Skin Temperature measurement was tested through the INA Robot Pimoroni's MLX90640.

The data analysis method (with the summary in Table 4) used in this thesis is Linear Regression Analysis using SPSS Statistics. Linear regression is the next step up after correlation (Figure 25). It is used when we want to predict the value of a variable based on the value of another variable. The variable we want to predict is called the dependent variable (or sometimes, the outcome variable). The variable we are using to predict the other variable's value is called the independent variable (or sometimes, the predictor variable). The independent variable (Y) used was the (BT) data where in the subject's temperature were taken using a digital thermometer. The dependent variable (X) analyzed is the IST, data taken using the INA- Pimoroni MLX90640 setup on INA-Robot.

Table 4. Calculation Summary

Sum of X = 231	Sum of Y = 255.17
Mean X = 33	Mean Y = 36.4529
Sum of squares (SSX) = 0.4	Sum of products (SP) = -0.451
Regression Equation = ŷ = bX + a	b = SP/SSX = -0.45/0.4 = -1.1275
a = MY - bMX = 36.45 - (-1.13*33) = 73.66036	ŷ = -1.1275X + 73.66036

For your data, the regression equation for Y is: ŷ = -1.1275X + 73.66036 and below is the graph showing the linear relationship between the two variables.

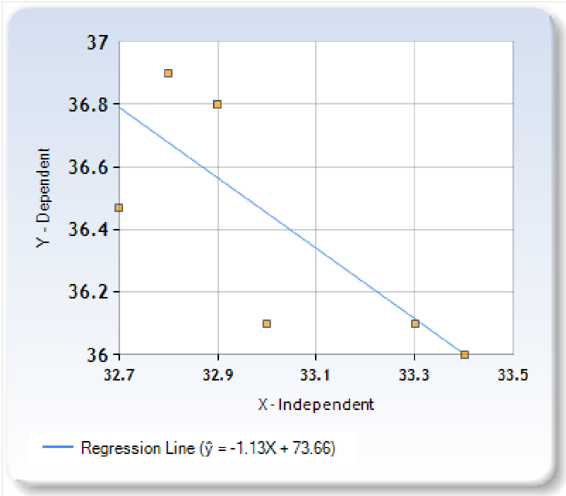


Figure 25. The relationship of the two variables hence it is linear, we can then use the formula to be able to create a dataset and compare with the SDT.

4. CONCLUSION

In the global fight against Covid-19, robotics has emerged as a crucial ally. Even advanced nations continue to grapple with this persistent challenge, facing difficulties in establishing a viable and effective system. The implementation of a workable solution remains expensive and resource-intensive, presenting several hurdles that must be addressed:

1) The development and testing of an effective robotics system are costly and complex, primarily due to safety and health considerations.
2) Successful integration of robotics requires a synergy of high-capacity Artificial Intelligence (A.I.), Internet of Things (IoT), Data Analytics, and Cloud Computing, a goal set for future research.
3) Devices and systems that handle customer and patient data raise data privacy concerns, often requiring meticulous paperwork for compliance.
4) The broader adoption of robotics with A.I. in healthcare settings, such as clinics and hospitals, remains uncertain. Some advocate for these systems, while others are hesitant due to potential workforce reduction.
5) The implementation of Digital Wellness technology is pivotal in combatting the pandemic, offering fundamental support.

Undoubtedly, A.I. and Robotics hold promise in patient treatment, surveillance, and early quarantine detection. However, accessibility to these innovations is not uniform across nations. Many countries face challenges in acquiring and implementing such technology, exacerbated by lockdowns, economic strains, and prioritizing basic necessities.

The Intelligent Nursing Assistant Robot (INA) has undergone rigorous testing, culminating in the successful integration of Raspberry Pi modules. An Android app enables remote control and autonomous movement of the robot. Further programming efforts are focused on Pixy Camera control, patient tracking, image capture via the Android app, temperature scanning, facial recognition, and comprehensive data acquisition. The final phase entails the systematic integration of all modules, encompassing data acquisition, monitoring, and logging. As we navigate these challenges, the potential of robotics in augmenting our response to the pandemic remains a beacon of hope.

Acknowledgement: The research has been funded by the Southern Taiwan University of Science and Technology & Republic of Taiwan.

References:

7inch capacitive touch screen LCD (H) with case, 1024×600, HDMI, IPS, various systems support. (n.d.). *Waveshare*. https://www.waveshare.com/7inch-hdmi-lcd-h-with-case.htm

Burton, A. C. (1935). Human calorimetry: The average temperature of the tissues of the body. *Journal of Nutrition, 9*, 261-280.

Cagebot科技寶工程積木：在家實現stem教育：機器人工程領域教具教材. (n.d.). Retrieved May 5, 2021, from https://www.cagebot.com/website/product_detailed/64/18

Cardona, M., Cortez, F., Palacios, A., & Cerros, K. (2020). Mobile robots application against Covid-19 pandemic. In *2020 IEEE ANDESCON*.

Cardona, M., Cortez, F., Palacios, A., & Cerros, K. (2020, October). Mobile robots application against covid-19 pandemic. In *2020 IEEE ANDESCON* (pp. 1-5). IEEE.

Guardian News and Media. (2016, September 19). The Thatcher illusion: Are faces special? *The Guardian*. https://www.theguardian.com/science/head-quarters/2016/sep/19/the-thatcher-illusion-are-faces-special

Harmouch, M. (2020, December 5). Haar Cascade Classifiers in OpenCV explained visually. *Medium*. https://medium.com/swlh/haar-cascade-classifiers-in-opencv-explained-visually-f608086fc42c

India, R. (2008, January 25). ROBO INDIA: Robotics India: Robots: Embedded system: Automation: Arduino: UAV: AVR. *RoboIndia*. https://roboindia.com/

Menon, S., Geroge, A., N, A., & James, J. (2021). Custom face recognition using YOLO.V3. In *3rd International Conference on Signal Processing and Communication (ICPSC), 2021*.

MLX90640 thermal camera breakout. (n.d.). *Pimoroni: Make Tech Treasure for Tinkerers*. https://shop.pimoroni.com/products/mlx90640-thermal-camera-breakout?variant=12536948654163

Park, J., Lee, S., & Cha, H. (2018). Accurate prediction of smartphones' skin temperature by considering exothermic components. In *2018 Design, Automation & Test in Europe Conference & Exhibition (DATE)* (pp. 1500-1503). https://doi.org/10.23919/DATE.2018.8342251

The World Health Organization. (n.d.). Coronavirus. *World Health Organization*. https://www.who.int/health-topics/coronavirus

What is app inventor? (n.d.). Retrieved May 5, 2021, from https://appinventor.mit.edu/explore/content/what-app-inventor.html

Xu, S. (2020, January 9). MLX90640 IR thermal camera working with Raspberry Pi 4. *Hackster.io*. https://www.hackster.io/steven-xu/mlx90640-ir-thermal-camera-working-with-raspberry-pi-4-d57177

Helen Grace Gonzales
University of Science and Technology
of Southern,
Philippines
Cagayan de Oro City
Philippines
helengrace.gonzales@ustp.edu.ph
ORCID 0000-0002-8072-9947