FACE MASK AND PHYSICAL DISTANCING DETECTION SYSTEM USING COMPUTER VISION

An Undergraduate Thesis

Presented to the Faculty of the

College of Information and Communications Technology

West Visayas State University

La Paz, Iloilo City

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Computer Science

by

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January 2022

Approval Sheet

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Acknowledgment

The researchers would like to express their deepest appreciation to the following persons, who in one way or another have made this work possible:

Dr. Ma. Beth S. Concepcion, Dean CICT, for the approval to conduct their study;

Dr. Frank I. Elijorde, Research Adviser, for the guidance all throughout the study;

Dr. Regin I. Cabacas, for the assistance in organizing their requirements.

Dr. Frank I. Elijorde, Arnel N. Secondes, Dr. Bobby D. Gerardo, and Ma. Luche Sabayle, panel members, for their fair judgement to the study and to the researchers;

The volunteers, for their time and effort extended during the testing phase;

The parents, guardians and friends for their moral, financial, and spiritual support that prompted the realization of this study;

The numerous others whom the researchers may have failed to mention but extended their help in many ways in the completion of this study.

And above all, the loving God, for the guidance, blessings, strength, faith, love, support and courage bestowed upon the researchers to pursue the study despite the difficulties.

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January 2022

Hugo Leroy D. Chavez; Flora May D. Gicanal; Christian T. Sarabia; Marianne Therese E. Tunggak; "Face Mask and Physical Distancing Detection System using Computer Vision". Unpublished Undergraduate Thesis, Bachelor of Science in Computer Science, West Visayas State University, Iloilo City, Philippines, January/July 2022.

Abstract

The present-day pandemic caused by the Coronavirus disease (COVID-19) made the world suffer from this dangerous disease where everyone's life stopped in the same way. The elongated lockdown period made lives impossible. The people have been detached from each other not only physically, but also socially. In order to mitigate the spread of COVID-19, governments across the globe responded by declaring various health protocols. This study and its outcome aim to further assist the mitigation by introducing neural network-based system to develop a method to identify a person if he or she is wearing a mask and to detect physical distancing. This concept builds upon the various existing insights that have been utilized yet enhancing it to a greater extent using Artificial Intelligence. The implementation of the study resulted to 99% accuracy in training and testing phases.

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CHAPTER 1 INTRODUCTION TO THE STUDY

Background of the Study and Theoretical Framework

The emergence of Coronavirus-2019 (COVID-19) outbreak has pushed the world into a corner in view of the fact that it has led to a dramatic loss of human life worldwide. Possessing a high infection rate, thousands fall victim to the virus in a swift manner of time. In order to mitigate the spread of COVID-19, governments across the globe respond by declaring various health protocols such as wearing face masks and face shields, routinely disinfection of hands, and social distancing practices. As such countermeasures are implemented in various governments to further limit the spread of COVID-19. Wearing masks, social distancing, and hand hygiene may contribute not only to the prevention of COVID-19, but also, to the decline of other infectious diseases (Chiu et al., 2020).

Researchers all over the world have spearheaded certain technological advances that managed to suppress the spread of COVID-19. The technologies Machine Learning and Computer Vision are prime examples. Implementations of these technologies such as Machine Learning will allow systems to automatically learn and improve based on experiences without having to be explicitly programmed. As for Computer Vision, this will allow systems to detect distinct objects that mimic human vision. With the use of different techniques to detect face masks and social distancing, this allows for an automated surveillance approach for reducing the spread of COVID-19.

The spread of COVID-19 can be limited if people strictly maintain social distancing and use a facial mask. Unfortunately, individuals do not follow these laws properly, thus, speeding up the spread of this virus. A solution to reducing the spread of coronavirus could be to identify people who do not comply with the rules, then, inform the corresponding authorities. A face mask detection is a technique for figuring out whether or not anyone is wearing a mask. It is similar to detecting any object from a scene and several systems have been developed.

With the ongoing COVID-19 pandemic, research has been prioritized for efficient mitigation of spreading the virus. With the introduction of Computer Vision and Deep Neural Networks, these architectures can be integrated. Recently, the growth of COVID-19 can be reduced by detecting facial masks in an urban city. This study will therefore be focused on using technology by implementing Computer Vision to reduce the spread of COVID-19.

This study aims to further assist the mitigation of the transmission of COVID-19 by introducing a Machine Learning AI with the help of Deep Neural Networks and Computer Vision. These algorithms that serve as the main framework will be utilized to develop a method to identify a person if he or she is wearing a mask, as well as, to detect if social distancing is maintained. This concept builds upon the various existing insights that have been used and continuously enhanced using Artificial Intelligence. Thus, this shows the need for a Face Mask and Physical Distancing Detection System using Computer Vision.

This study will be conducted to determine whether or not a face mask and distancing recognition system can provide assistance in preventing the transmission of the COVID-19 virus between individuals.

Theoretical Framework

Theoretical framework below shows the implementation of the system regarding to the problem presented in the study.

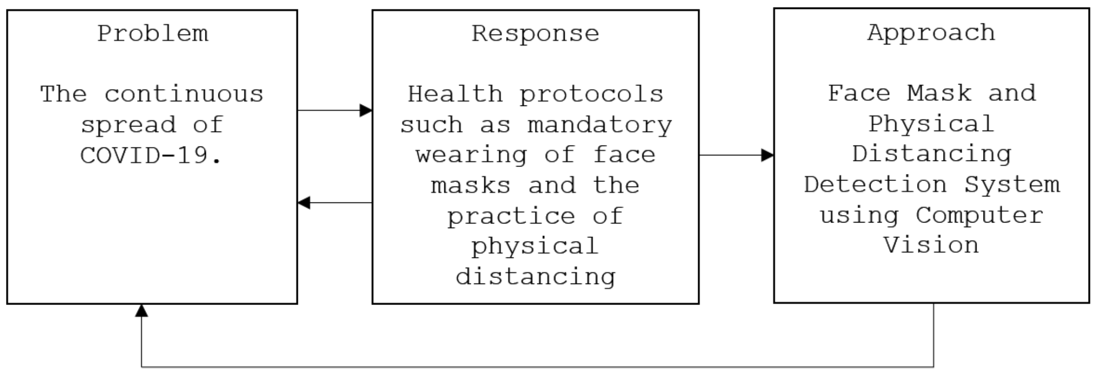

Figure 1. A schematic diagram showing the relationship between the problem, response and the approach of the study.

Based on the figure shown, the problem is the continuous spread of COVID-19, in which the Government responded by implementing health protocols. The researchers then proposed an approach which is "Face Mask and Physical Distancing Detection System Using Computer Vision" to aid the response against the problem.

Objectives of the Study

The study sought to achieve its general objective of developing a system that detects face masks and physical distancing as a means to aid the prevention of COVID-19.

Specifically, it aimed to:

1. Develop a deep neural network-based algorithm that can detect face masks on individuals and the physical distance between them;

2. Measure the accuracy of the system in terms of face mask detection and observance of physical distancing; and

3. Provide authorities a means that monitors individuals if they are following the minimum health safety protocols.

Significance of the Study

The results of the proposed study will contribute in reducing the spread of COVID-19 in the society. The aforementioned results will be beneficial to the following:

Health Practitioners/Healthcare Professionals- This study will help health practitioners in preventing the spread of the virus in their workplace or environment. It would also enhance their safety by lessening the chances of acquiring the virus and help reduce the intensity of their workload by having less numbers of patients with cases of the COVID-19.

Local Government Units (LGUs)- This study will be able to assist the LGUs in improving their response to the COVID-19 crisis. It can assist in maintaining the face mask and social distancing health protocols among the people especially in crowded public places.

Establishment Owners- This study will be beneficial to establishment owners in monitoring people to follow the said health protocols. Also, this would improve the safety of their employees from acquiring the virus, which allows them to provide quality service to customers.

The General Public- The general public would benefit from this study since it would improve their safety when going to places with numbers of people. This can also aid in reminding them to follow the safety protocols as they roam around their environment.

Future Researchers- The findings of the study will equip valuable knowledge to future researchers on how the system works. They can use the study to further develop the system or encourage them to create their own system as an alternate approach to the spread of COVID-19.

Definition of Terms

For better understanding, the following terms were defined conceptually and operationally:

Accuracy- is used to describe anything that is near to true value or the recognized standard. In other words, how close the result is to the correct value, regardless of how precisely it is expressed (https://www.computerhope.com/jargon/a/accuracy.htm).

In this study, the term '*accuracy*' refers to an element of the system to measure how effective is its detection.

Automated Predictions- refers to the output of an algorithm after it has been trained on a historical dataset and applied to new data (https://www.datarobot.com/wiki/prediction/#:~:text=What%20does%20Prediction%20mean%20in,will%20churn%20in%2030%20days.).

In this study, the term '*automated predictions*' refers to how the trained face mask detection model and the pre-trained physical distancing detection behave and predict objects.

Computer Vision- a field of Computer Science and Artificial Intelligence that focuses on giving computers the ability to have a higher level of understanding of concepts through the use of videos or images (https://www.meetbunch.com/terms/computer-vision).

In this study, the term '*computer vision*' refers to the discipline of the study's system to analyze face masks and physical distancing.

Coronavirus (COVID-19)- a potentially severe, primarily respiratory illness caused by a coronavirus and characterized by fever, coughing, and shortness of breath (https://www.dictionary.com/browse/covid-19).

In this study, the term '*Coronavirus*' refers to the disease considered pandemic that needs to be prevented. The prevention will be through the implementation of the health protocols with the use of the system developed by the researchers.

Deep Learning- An artificial intelligence (AI) function that imitates the workings of the human brain in processing data and creating patterns for use in decision making (https://www.investopedia.com/terms/d/deep-learning.asp).

In this study, the term '*deep learning*' refers to the method used to process the data and for the decision making in mask and distance detection.

Deep Neural Networks- a neural network with a certain level of complexity; a neural network with more than two layers (https://www.techopedia.com/definition/32902/deep-neural-network).

In this study, the term '*deep neural networks*' refers to the module used by OpenCV as the backbone architecture of the system.

Face Mask- a covering (as of polypropylene fiber or cotton fabric) for the mouth and nose that is worn specially to reduce the spread of infectious agents (such as viruses or bacteria) (https://www.merriam-webster.com/dictionary/face%20mask).

In this study, the term '*face mask*' refers to the object such as a piece of cloth that individuals use to cover the nose and mouth to prevent contracting COVID-19. It is also subject to detection of the system developed in this study.

Face Mask Detection- refers to detect whether a person is wearing a mask or not (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8223067/).

In this study, the term '*face mask detection*' refers to the features of the system to detect an individual if he/she is wearing a mask or not.

Health Protocols- are frameworks outlining the guidelines that will be provided to the general public to follow to prevent endangering their health (https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html).

In this study, the term '*health protocols*' refers to the purpose of the system to make sure that individuals follow these rules and guidelines by the IATF.

Machine Learning- The use and development of computer systems that are able to learn and adapt without following explicit instructions, by using algorithms and statistical models to analyze and draw inferences from patterns in data (https://www.lexico.com/definition/machine_learning).

In this study, the term '*machine learning*' is defined as the system that has the ability to automatically learn the datasets and gradually improve its accuracy.

Physical/Social Distancing- the practice of maintaining a safe or appropriate physical distance from other people, or the measures taken to reduce close physical contact, especially to slow the spread of a contagious illness or disease (https://www.dictionary.com/browse/social-distancing).

In this study, the term '*social distancing*' refers to the practice of distancing of individuals from each other. The six-feet distance among individuals is subject to detection of the system which will be developed in this study.

Structural Algorithms- are analytic tools used throughout technologies to improve quality by increasing accuracy while saving valuable time (https://smallbusiness.chron.com/definition-data-structure-algorithms-27214.html).

In this study, the term '*structural algorithms*' refers to the algorithms such as neural networks used by the researchers to develop the system.

Delimitation of the Study

This study entitled, "Face Mask and Physical Distancing Detection System using Computer Vision", is designed to understand the use of the face mask and physical distancing detection system; therefore, the intent of this study is to provide a resolution to reduce the transmission of COVID-19 and influence modern society by wearing a face mask and follow physical distancing against the outbreak prevailing today. However, the study has focused on the following:

- The proposed automated system should recognize face masks on an individual and physical distancing between individuals in real-time.
- The system should notify the responsible personnel/management if someone violates health protocols.

Due to the ongoing quarantine protocols in the region, the testing of the system will be carried out in the researchers' respective homes using pre-recorded videos to observe its capabilities. The results of the study conducted will be collected to determine whether or not a facemask and physical distancing detection system is effective against the spread of COVID-19.

Structural algorithms, automated predictions, modules, and statistical tools will be carried through by the researchers in this study to fulfill the declared objectives. Furthermore, this study does not offer complete resolution to the problem, but solely as a means to help reduce the transmission of COVID-19.

CHAPTER 2 REVIEW OF RELATED STUDIES

Review of Existing and Related Studies

Related Literature

Application of Machine Learning and Artificial Intelligence on COVID-19

Machine Learning and Artificial Intelligence are methods employed by various healthcare providers. According to Lalmuanawma et al. (2020), recent studies using such technology are augmenting the researchers in multiple angles by addressing the troubles and challenges while using such algorithms in assisting medical experts in real-world problems.

Their study shows that the use of modern technology with AI and ML dramatically improves the screening, prediction, contact tracing, forecasting, and drug/vaccine development with extreme reliability. However, most of the models are not deployed enough to show their real-world operation, but these models are still up to the mark to tackle the pandemic.

In the process of monitoring a large population, authorities need a solution to control the implementation of the countermeasures, which starts with the availability of data quickly and accurately. With this profound elucidation between the countermeasures against COVID-19 and the involvement of artificial intelligence and machine learning, this had brought on the fact that the study can serve as the coalescence of both ideas offering as a solution. This solution has been utilized by the researchers by developing an automated system to eliminate the need of manual labor of observing individuals who wear masks and follow social distancing and those who do not, thus, further reducing the spread of COVID-19.

A survey of the recent architectures of deep convolutional neural networks

A survey conducted by Khan et al. (2020) about Deep Convolutional Neural Network (CNN) has shown exemplary performance in several competitions related to Computer Vision and Image Processing. Some of its application areas include Image Classification and Segmentation, Object Detection, Video Processing, Natural Language Processing, and Speech Recognition. This survey thus, focuses on the intrinsic taxonomy present in the recently reported deep

CNN architectures and, consequently, classifies the recent innovations in CNN architectures into seven different categories. These seven categories are based on spatial exploitation, depth, multi-path, width, feature-map exploitation, channel boosting, and attention. Additionally, the elementary understanding of CNN components, current challenges, and applications of CNN are also provided.

Computer Vision for COVID-19 Control: A Survey

Ulhaq et al. (2020) conducted a survey about Computer Vision and its applications for COVID-19 Control, the study shows recent success in solving various complex problems in health care and has the potential to contribute to the fight of controlling COVID-19. The researchers divide the described methods into three categories based on their role in disease control: Computed Tomography (CT) scans, X-ray Imagery, and Prevention and Control with detailed summaries of preliminary representative work, including available resources to facilitate further research and development. Consequently, the researchers concluded that the survey can be considered only as an early review since many computer vision approaches are being proposed and tested to control COVID-19 pandemic at the current time.

Related Studies and Systems

COVID-19 Risk Assessment through Multiple Face Mask Detection using MobileNetV2 DNN

Guillermo et al. (2020), developed an active face masks detection and monitoring system to help authorities to identify people who might be vulnerable to COVID-19. Due to the lack of reliable and prompt means to identify COVID-19 cases in the Philippine Government, and without risking the exposure of personnel in areas COVID-19 cases, an artificial neural network-based system capable of detecting if people in the crowd are wearing face masks using MobileNetV2 DNN has been created by the authors. The results showed that the system achieved almost 100% accuracy and minimal loss despite using an artificial dataset and no videos included.

Real-Time Facemask Recognition with Alarm System using Deep Learning

Militante and Dionisio (2020) developed a system that detects facemask in real-time with an embedded alarm. The system develops a Raspberry Pi-based real-time facemask recognition that alarms and captures the facial image if the person detected is not wearing a facemask. The dataset they used contains 25,000 images using 224x224 pixel resolution and their system achieved an accuracy rate of 96% as to the performance of the trained model. This study is beneficial in combating the spread of the virus and avoiding contact with the virus.

An Automated System to Limit COVID-19 Using Facial Mask Detection in Smart City Network

Rahman et al. (2020), proposed a system that restricts the growth of COVID-19 by finding out people who are not wearing any facial mask in a smart city network where all the public places are monitored with Closed-Circuit Television (CCTV) cameras. The study focuses on deep learning architecture that is trained on a dataset that consists of images of people with and without masks collected from various sources. Based on the results, the trained architecture achieved 98.7% accuracy on distinguishing people with and without a facial mask for previously unseen test data.

RetinaMask: A Face Mask detector

Jiang et al. (2020) proposed a system called RetinaFaceMask, which is a one-stage detector that consists of a feature pyramid network to fuse high-level semantic information with multiple feature maps, and a novel context attention module to focus on detecting face masks. The results of the system show that RetinaFaceMask achieves state-of-the-art results on a public face mask dataset with 2.3% and 1.5% higher than the baseline result in the face and mask detection precision, respectively, and 11.0% and 5.9% higher than baseline for recall. The authors also explored the possibility of implementing RetinaFaceMask with a light-weighted neural network MobileNet for embedded or mobile devices.

Synthesis

The Review of Existing and Related Studies discusses the implementation of Machine Learning, Deep Neural Networks, and Computer Vision and its advantages. In depth, the content of the related studies depicts the pros and cons of using the said algorithms and the difficulties of testing their systems. This includes developing and testing of algorithms and systems by trial and error to an extent where a system will be able to achieve 90% and above accuracy. With the following algorithms and models discussed such as MobileNet and OpenCV that show excellent accuracy and performance, the researchers develop a face mask and physical detection system that utilizes the said elements. Lastly, the Review of Existing and Related Studies discusses the factors, relations, and the current stasis of the community in the pandemic that influenced and aided the researchers in their study.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

Description of the Proposed Study

Face Mask and Physical Distancing Detection System using Computer Vision is a Research and Development Project which will be developed by the researchers to detect facemasks and physical distancing on individuals using an Observational Design. Observational Design, in this study, focuses on documenting the performance of the system based on the observation of behaviors shown by individuals.

The system will utilize computer vision with a classification and prediction model to predict and analyze the data.

Assumptions and Preconditions

The study is anchored on the assumption that the researchers acquired a written permission to conduct the study from the college authorities. Subsequently, the researchers will gather and procure pre-recorded surveillance videos with heavy foot traffic to be used as the testing data for the study to proceed.

Methods and Proposed Enhancements

Methods

The system’s main source code is written in Python and utilizes the process of Deep Neural Networks (DNN)and Computer Vision which is to identify and categorize images from learned features. It is very effective in a multi-layered structure when obtaining and assessing the necessary features of graphical images.

The first step in predicting whether an individual has worn a mask correctly is to train the model with a proper dataset. After the classifier has been trained, a face detection model must be used to detect faces so that the model can classify whether or not an individual is wearing a mask. The researchers will test the model along with the proposed enhancements to the system to evaluate its accuracy.

The aim of this research is to discover how accurate and efficient the system's face mask and physical distancing detection is. The researchers will use a Deep Neural Network (DNN) module from OpenCV with object detection as the backbone architecture of the device. This approach will help in detecting faces in real time, even on devices like Raspberry Pi. The classifier predicts whether a person is wearing a mask or not using a pre-trained model MobileNetV2 from TensorFlow.

Dataset Acquisition

The dataset to be used for training the face detection model in this study requires two sets of images of faces with masks and without masks to balance the dataset. The motive of having a balanced dataset is to prevent the risk of having the model become heavily biased. The researchers gathered a total of 1560 images from Kaggle which contains images with people wearing face masks and without face masks.

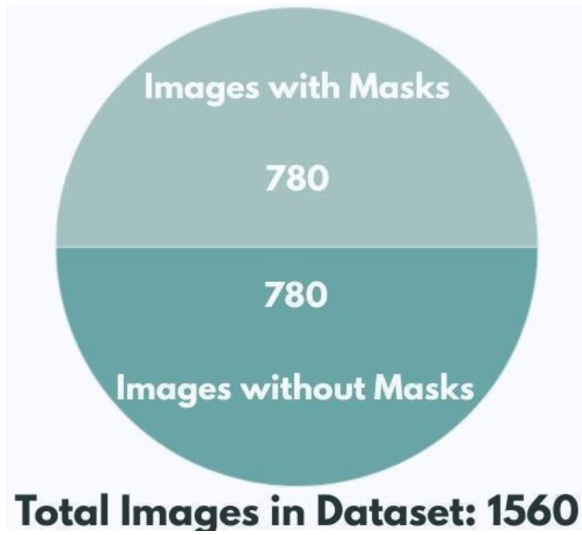

Fig. 2. Pie Chart of the total images in the dataset

Fig. 3. Sample images from the dataset of people with face masks and without face masks

Training of Face Mask Detection Model

Overall, a total of 1560 images, with and without masks were used as a dataset to train the model. These images were preprocessed, then used to train the MobileNetV2 classifier model. Preprocessing processes include the resizing of images then converted to array format and the scaling of pixels of the input image. The model was pre-trained with ImageNet weights before the face mask detection training. The researchers based the following parameters constants below from Guillermo et al. study owing to the fact that they also utilize MobileNetV2 model.

- initial learning rate = 0.0001
- total number of training epochs = 20
- batch size = 32

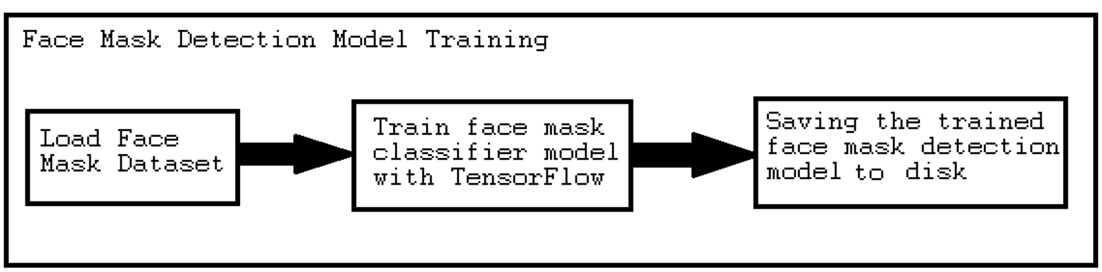

Fig. 4. Training Flow of the Model

After fulfilling the prerequisites, the model is trained using Spyder IDE. Results of the training have been published in the Spyder IDE and was saved as a newly trained model. The results of this training which included the training accuracy and loss curves will be discussed on the Training Phase section on Chapter 4.

The researchers chose to use MobileNetV2 classifier model for the system to detect face masks as this architecture is highly efficient and can be applied to devices with limitations on computing capability (Sukvichai et al.).

Testing of Face Mask and Physical Distancing Detection

The researchers will utilize the trained face mask detection model and physical distancing detection model as an enhancement in the testing phase. By running the main executable file, the system will load the models and perform the process to detect faces and human body, and apply the face mask classifier and physical distancing classifier to predict face masks and physical distancing.

The researchers will be using separate data for the testing phase.

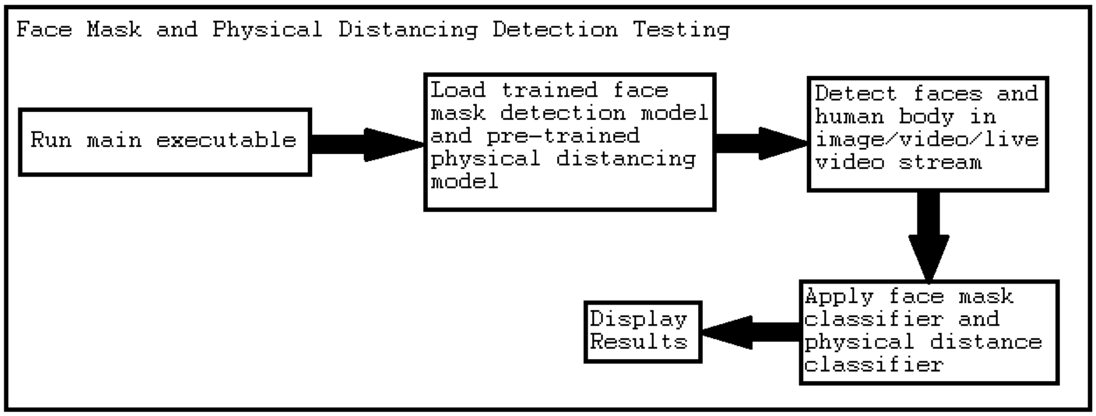

Fig. 5. Testing Flow of the System

The system will show a window which presents the images, video, or live video stream to display the results and labels on the faces and body. Labels include the identified classification "mask" in green and "no mask" in red with the probability percentage alongside the classified item. For the physical distancing classification, a box and color label include the identified classification in green and in red.

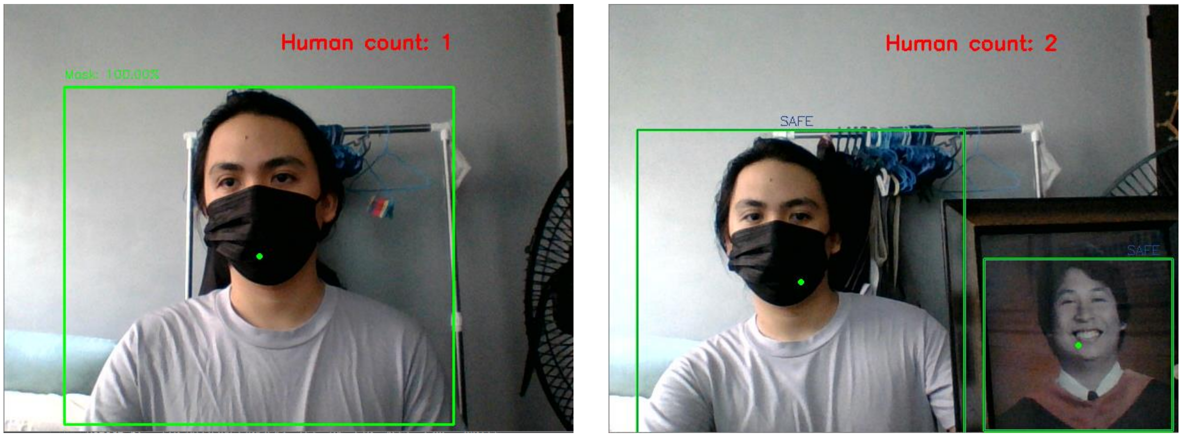

Fig. 6. Mockup results of the system, Face Mask Detection (left), and Physical Distancing Detection (right)

Proposed Enhancements

The researchers propose an enhancement which is not present in the previous researches cited in the related studies and to further fulfill the study's objectives which is an algorithm that detects physical distancing between individuals. As the name suggests, physical distancing or social distancing implies that individuals must physically distance themselves from one another, reducing close contact, thus, reducing the spread of COVID-19.

Object Detection Algorithm for Physical Distancing Detection

Object Detection algorithms aim to identify all target objects in the target image and determine the categories and position information in order to achieve computer vision understanding. The researchers will implement the YOLO object detection algorithm for physical distancing detection because the unified architecture of YOLO is extremely fast. The base YOLO model processes images in real-time at 45 frames per second which outperforms other detection methods such as Deformable Part Model (DPM) and Region-based Convolutional Neural Networks (R-CNN).

Components and Design

System Architecture

Face Detection using OpenCV DNN

The face detection model is a pre-trained model developed by OpenCV which uses Haar Cascade algorithm to identify faces in an image or real time video. By integrating this model to the system, it would be able to track an individual's face.

Classification of images using MobileNetV2

MobileNetV2 is a deep learning model that is based on Convolutional Neural Network which consists of several layers and functions to work. This DNN will be utilized by the researchers for the classification of images. The face detection model will be trained using the required dataset for the model to work properly.

Physical Distancing Detection using OpenCV YOLO object detection

YOLO (You Only Look Once) is a real-time object recognition/detection algorithm. The researchers will use a pretrained model which is YOLOv3 to perform the detection of individuals and the distance between them.

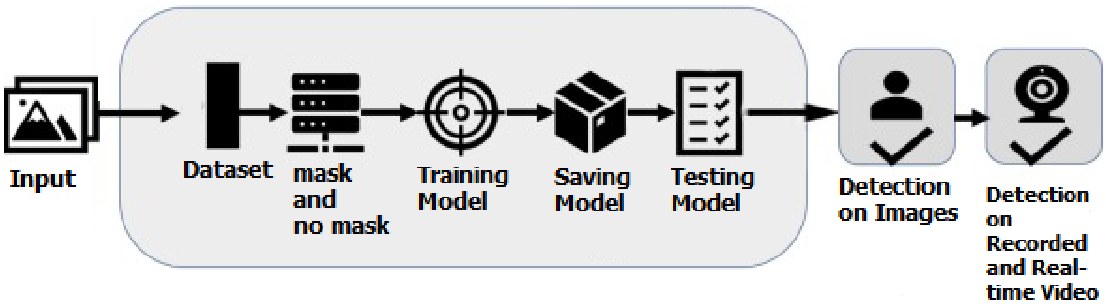

Fig. 7. The flow diagram of the algorithm of the system. Based from SSDMNV2 model diagram (Nagrath et al., 2020)

Other Features

A feature such as alert notifications will be added. The alert notification will trigger when the system detects people who classify as someone who did not wear a mask properly and did not follow physical distancing. The alert notifications will produce an automated alert speech and a toast notification in the user's computer.

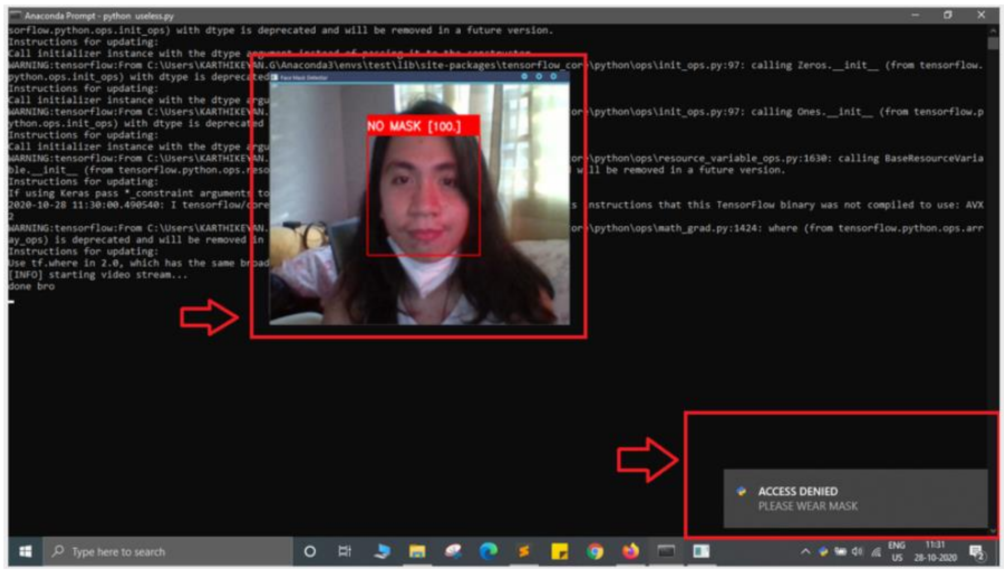

Fig. 8. Sample notification of the system on a computer

CHAPTER 4 RESULTS AND DISCUSSION

Implementation

The implementation of the system requires the researchers to train the face mask model and gather testing data such as pictures of people wearing a face mask and not wearing a facemask and static videos such as CCTV feeds. With all the fundamental requirements met, the researchers performed the training of the face mask model and consequently the testing of the system through the Spyder IDE.

After training the face mask model, the researchers gathered the testing data locally and from various publicly available sources. Hence, the researchers implemented and tested the system using the gathered testing data to identify the system’s effectiveness and capability to detect face masks and physical distancing.

Results Interpretation and Analysis

Training Phase

In summary, here are the parameters used and equivalent learning rates for each epoch associated with the training of the face mask detection model.

Table 1. Parameter Constants

Initial Learning Rate	0.0001
Epoch	20
Batch Size	32
Training Dataset	1560
Decay	0.000005
Weight Updates	78

Table 2. Learning Rate Mapping with Epoch

Epoch - Learning Rate (α)			
0	0.000100000	10	0.000099612
1	0.000099984	11	0.000099573
2	0.000099922	12	0.000099534
3	0.000099883	13	0.000099500
4	0.000099844	14	0.000099457
5	0.000099805	15	0.000099418
6	0.000099765	16	0.000099380
7	0.000099728	17	0.000099341
8	0.000099689	18	0.000099303
9	0.000099650	19	0.000099264

The first three parameters (Initial Learning Rate, Epoch, and Batch Size) in Table 1 are set by the researchers based on the training algorithm of the fame mask detection model, and the fourth parameter (Training Dataset) was based on the total gathered data from the datasets. For parameters decay and weight updates, refer to the formulas below:

$$Decay = \frac{Initial\ Learning\ Rate}{Epoch} \tag{1}$$

$$Weight\ Updates = \frac{Training\ Dataset}{Epoch} \tag{2}$$

To get the Learning Rate (α) for each epoch, the formula is:

$$Learning\ Rate\ (\alpha) = Initial\ Learning\ Rate\ * \ \frac{1}{1\ +\ (Decay(Epoch\ Number * Weight\ Updates))} \tag{3}$$

Based on the data from Table 2, it can be seen that the learning rate decreases as the number of epoch increases. This behavior suggests that the neural network undergoes smaller steps in learning, allowing it to descend into areas of the loss landscape that are further optimal, that is to say, it obtains higher accuracy by finding an area with rationally low loss. The results of training of face mask detection model is shown in the figures below:

	precision	recall	f1-score	support
with_mask	0.99	0.99	0.99	383
without_mask	0.99	0.99	0.99	384
accuracy			0.99	767
macro avg	0.99	0.99	0.99	767
weighted avg	0.99	0.99	0.99	767

Fig. 9. Face Mask Detection Model Training Evaluation

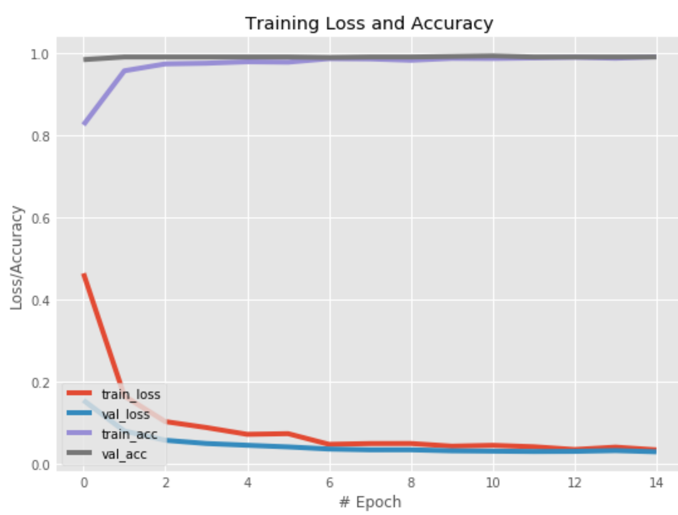

Fig. 10. Training Loss and Accuracy Plot

Based on Fig. 10 or Training Loss and Accuracy Plot, the curves for training accuracy and loss are almost linear at a value of 1 and 2, hence, the face mask model almost achieves 99% accuracy and minimal loss. Meanwhile on Fig. 9, Face Mask Detection Model Training Evaluation, the values accuracy, precision recall, and F1 score are all approximately 99%.

Testing Phase

To evaluate the accuracy of the trained face mask detection model along with the pre-trained physical distancing detection model, the researchers used the gathered testing data which are distinct from the dataset used from the training phase. Images and static video feeds from webcam and smartphones were also tested. The results are shown below:

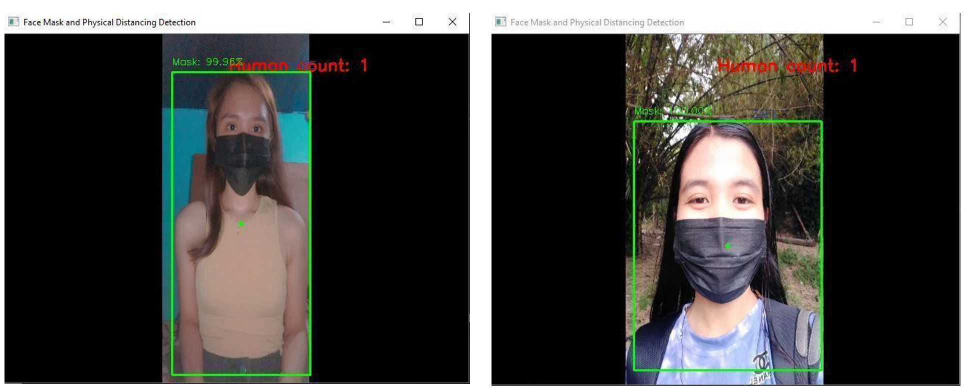

Fig. 11. Single face images with masks test data (face images of researchers)

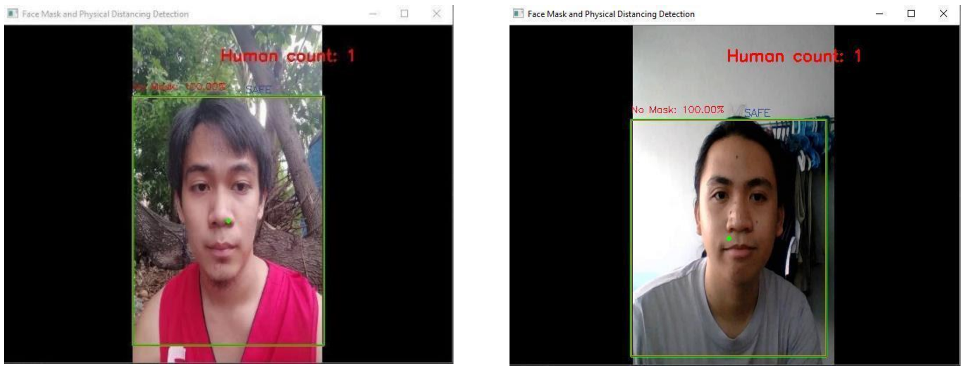

Fig. 12. Single face images without masks test data (face images of researchers)

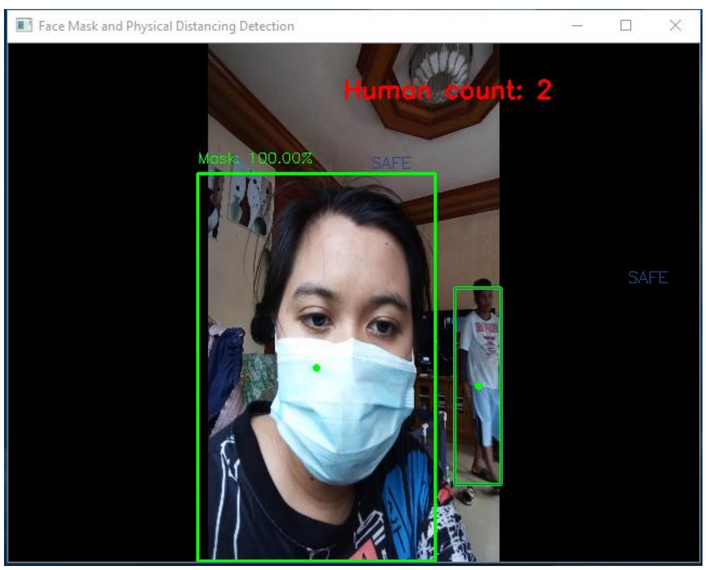

Fig. 13. Image with mask and multiple individuals test data (face image of volunteers)

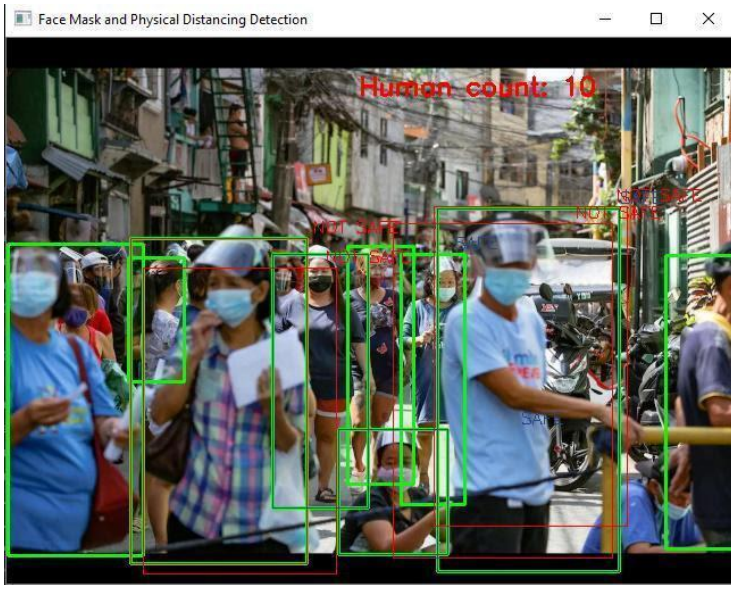

Fig. 14. Image with multiple individuals with masks from test data (from publicly available images)

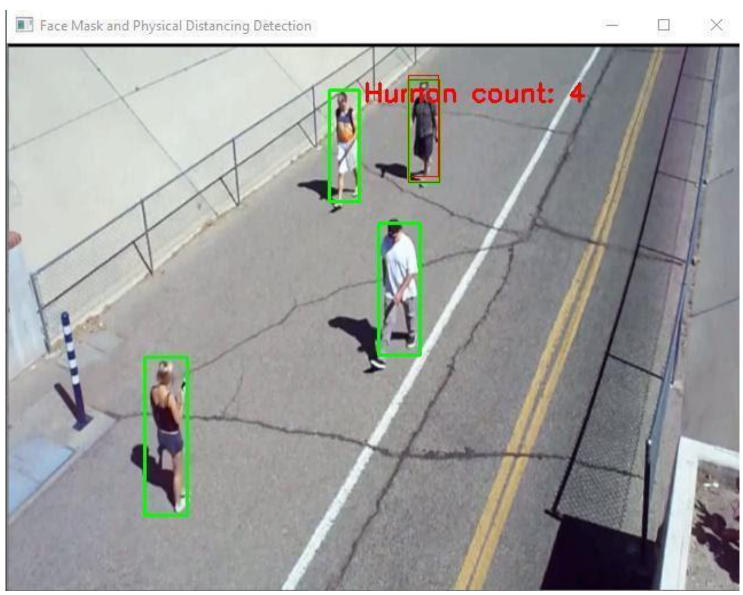

Fig. 15-a. Static video frames test data (from www.kaggle.com)

Fig. 15-b. Static video frames test data (from www.kaggle.com)

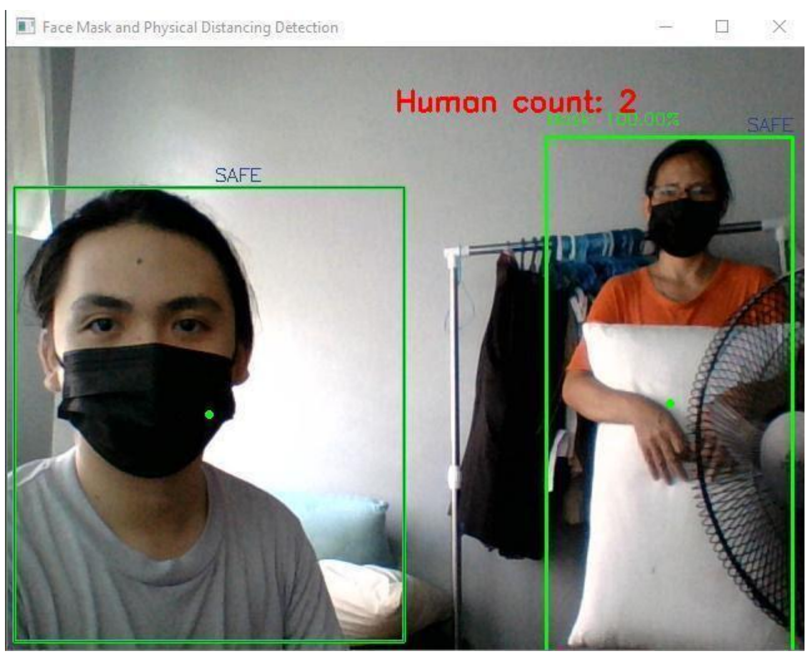

Fig 16-a. Video Stream Frames Test Data

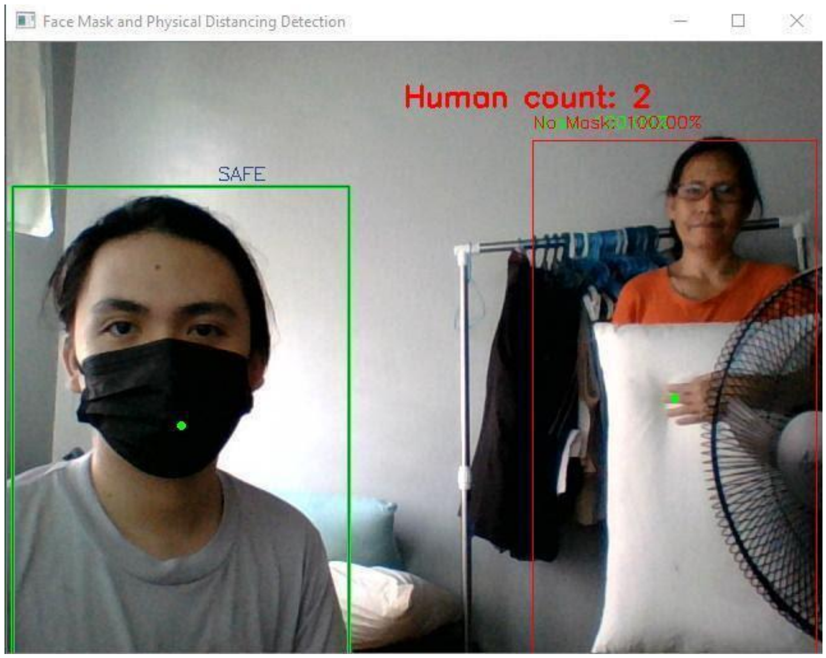

Fig 16-b. Video Stream Frames Test Data

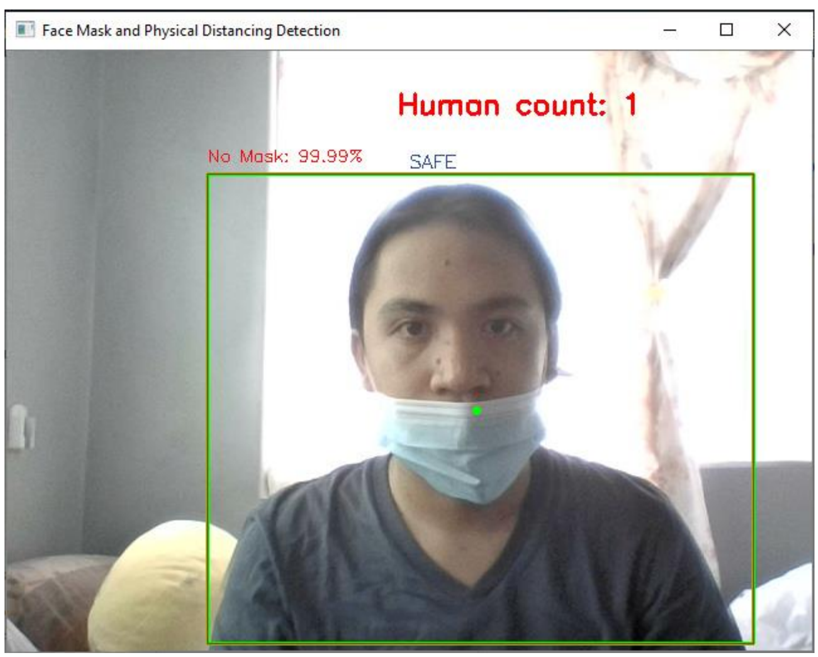

Fig 16-c. Video Stream Frames Test Data (Improper Wearing of Facemask)

From the images and video frames provided above, the probability percentage of classified items between "mask" or "no mask" is approximately 99%. As the risk of getting COVID-19 is higher in crowded places, the researchers also tested the multiple face mask detection and physical distancing system in videos with mass gathering. See Figures 14 to 15-b.

System Evaluation Results

Based on Fig. 10 or Training Loss and Accuracy Plot, the face mask model achieved approximately 99% accuracy and minimal loss which were derived from the curves for training accuracy and loss which were practically linear at a value of 1 and 2. Meanwhile on Fig. 9 or Face Mask Detection Model Training Evaluation, values such as accuracy, precision recall, and F1 score achieved approximately 99%. Accuracy measures the actual correctly predicted observation over all observations while high precision measures the low false positive rate. High recall shows that almost all correctly classified items were predicted correctly. F1 score refers to the weighted average of precision and recall. The fact that all of these metrics are at 99% indicates that the classifier model's predictions are accurate. This was further demonstrated by the testing findings depicted in the figures in the Testing Phase.

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Proposed Study Design and Implementation

This study entitled "Face Mask and Physical Distancing Detection System using Computer Vision" was conducted to develop a neural network-based system that can detect face masks and physical distancing in the matter of the present outbreak disease, namely COVID-19, and also to determine if the system is accurate and effective on its detection to mitigate the spread of COVID-19. In addition, the researchers would also determine if the system developed in the study is accurate in terms of detecting face masks and physical distancing to provide authorities a means that monitors minimum health safety protocols to further constrict the spread of COVID-19 locally.

Based on the results gathered and interpreted by the researchers, the following findings were made:

1. The system's performance is accurate in terms of face mask detection.
2. The system's performance is accurate in terms of physical distancing detection.

Summary of Findings

Derived from the results in both training phase and testing phase, the researchers observed that the system attained a level of suitability in its performance. The training of the face detection model achieved 99% accuracy, and the testing of the face detection model alongside with the physical distancing detection algorithm have also achieved 99% accuracy in prediction in terms of wearing of face mask and physical distancing observation, with these findings, the system developed by the researchers is accurate in terms of its performance.

Conclusions

By using the dataset gathered for the training of the face mask detection model, the accuracy and performance of the system is remarkable considering that it achieved almost 99% accuracy in the Training Phase. Nonetheless, the researchers still recommend further training of the face mask detection model with datasets that consist precise images and video feeds of face masks with the intention to maintain exceptional performance when tested on different video conditions and where increased individuals are needed to be detected by the system.

Recommendations

After conducting the study, the researchers of Face Mask and Physical Distancing Detection System using Computer Vision, recommend the following:

1. The system developed by this study be further enhanced and introduced to the LGUs. In this present time, where the community are yet to recover from the impact of the COVID-19 pandemic, the mitigation of the virus is the utmost priority.

2. Future researchers, should utilize this study to provide additional assistance in their research studies and add enhancements such as identifying an individual if he/she is vaccinated to aid authorities to control and respond faster to pandemic situations.

3. While the study is a great step to reduce the spread of COVID-19 in crowded places, it should not be

halted including existing health protocols until there is already a secured protection against the disease.

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Appendices

Appendix A

Letter to the Adviser

Attachment 3

	INVITATION LETTER FOR ADVISER	Document No.	WVSU-ICT-SOI-03-F03
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

March 8, 2021

Frank I. Elijorde
Professor III
West Visayas State University
Luna St., La Paz, Iloilo City 5000
Iloilo, Philippines

Dear Sir Elijorde,

The undersigned are BS in Computer Science Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is *"Face Mask Detector with Machine Learning Implementation as a COVID-19 Prototype Security Device"*.

Knowing of your expertise in research and on the subject matter, we would like to request you to be our **ADVISER**.

We are positively hoping for your acceptance. Kindly check the corresponding box and affix your signature in the space provided. Thank you very much.

Respectfully yours,

1. Christian Sarabia,
2. Flora May Gicanal,
3. Marianne Therese Tunggak,
4. Hugo Leroy Chavez,

PS:

Advisers, are task to work with the students in providing direction and assistance as needed in their thesis/capstone project. They shall meet with the students weekly or as needed to provide direction, check on progress and assist in resolving problems until such a time that the students passed their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

Action Taken:

❍ I Accept.

❍ Sorry. I don't accept.

Signature over printed name of the Adviser

CC:

CICT Dean
Research Coordinator
Group
*To be accomplished in 4 copies

Appendix B

Sample Program Codes

main.py

```
from tensorflow.keras.applications.mobilenet_v2 import preprocess_input
from tensorflow.keras.preprocessing.image import img_to_array
from tensorflow.keras.models import load_model
from win10toast import ToastNotifier
import numpy as np
import imutils
import time
import cv2
import math
from modules.detection import detect_people
from scipy.spatial import distance as dist
from modules.config import camera_no

toaster = ToastNotifier()


labelsPath = "yolo-coco/coco.names"
LABELS = open(labelsPath).read().strip().split("\n")
np.random.seed(42)
COLORS = np.random.randint(0,
                        255,
                        size=(len(LABELS), 3),
                        dtype="uint8")

weightsPath = "yolo-coco/yolov3.weights"
configPath = "yolo-coco/yolov3.cfg"

net = cv2.dnn.readNetFromDarknet(configPath, weightsPath)

# face mask classification
confidence_threshold = 0.4


if True:
    # set CUDA as the preferable backend and target
    print("")
    print("[INFO] Looking for GPU")
    net.setPreferableBackend(cv2.dnn.DNN_BACKEND_CUDA)
    net.setPreferableTarget(cv2.dnn.DNN_TARGET_CUDA)


# load our serialized face detector model from disk
print("loading face detector model...")
prototxtPath = "models/deploy.prototxt"
weightsPath = "models/res10_300x300_ssd_iter_140000.caffemodel"
faceNet = cv2.dnn.readNet(prototxtPath, weightsPath)

# load the face mask detector model from disk
model_store_dir= "models/classifier.model"
maskNet = load_model(model_store_dir)

cap = cv2.VideoCapture(camera_no)       #Start Video Streaming
```

train_mask_detector.py

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications import MobileNetV2
from tensorflow.keras.layers import AveragePooling2D
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense
from tensorflow.keras.layers import Input
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.applications.mobilenet_v2 import preprocess_input
from tensorflow.keras.preprocessing.image import img_to_array
from tensorflow.keras.preprocessing.image import load_img
from tensorflow.keras.utils import to_categorical
from sklearn.preprocessing import LabelBinarizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from imutils import paths
import matplotlib.pyplot as plt
import numpy as np
import argparse
import os

# construct the argument parser and parse the arguments
ap = argparse.ArgumentParser()
ap.add_argument("-d", "--dataset", required=True,
    help="path to input dataset")
ap.add_argument("-p", "--plot", type=str, default="plot.png",
    help="path to output loss/accuracy plot")
ap.add_argument("-m", "--model", type=str,
    default="classifier.model",
    help="path to output face mask detector model")
args = vars(ap.parse_args())

# initialize the initial learning rate, number of epochs to train for,
# and batch size
INIT_LR = 1e-4
EPOCHS = 20
BS = 32

# grab the list of images in our dataset directory, then initialize
# the list of data (i.e., images) and class images
print("[INFO] loading images...")
imagePaths = list(paths.list_images(args["dataset"]))
data = []
labels = []
```

Appendix C

Disclaimer

This software project and its corresponding documentation entitled “Face Mask and Physical Distancing Detection System using Computer Vision” is submitted to the College of Information and Communications Technology, West Visayas State University, in partial fulfillment of the requirements for the degree, Bachelor of Science in Computer Science. It is the product of our own work, except where indicated text.

We hereby grant the College of Information and Communications Technology permission to freely use, publish in local or international journal/conferences, reproduce, or distribute publicly the paper and electronic copies of this software project and its corresponding documentation in whole or in part, provided that we are acknowledged.

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Marianne Therese E. Tunggak

January 2022