CHAPTER 1 INTRODUCTION TO THE STUDY

Background of the Study and Theoretical Framework

Coronavirus disease 2019 (COVID-19) was discovered and reported in Wuhan, China, by the end of 2019. The World Health Organization declared the outbreak of the virus rapidly spreading and is profoundly affecting lives around the globe. Countries impose protocols and use various strategies to control the spread of the virus (Shereen, 2020; McLeod, 2020; Secon, 2020). Governments strictly enforced behavioral interventions and are being followed by the public, one of these interventions is social distancing.

Social distancing is a series of behavioral measures aimed at limiting the transmission of an infectious disease by maintaining a physical space between people and reducing their physical contact frequency (Harris et al., 2020; Johnson et al., 2020). Restrictions on social gatherings resulted in the closing of schools, churches, and mass gatherings such as weddings and funerals were banned to prevent overcrowding. It has been proven and was effectively used in the history of global diseases (Bell, 2004; Hatchett et al., 2007; Wardrop, 2009).

The spread of the infection can be diminished by limiting the probability of an uninfected individual coming into personal touch with an infected person resulting in fewer deaths (Johnson, Sun, & Freedman 2020). Despite the limits that people are ruled by, technology brought new solutions to the limits enabling individuals to continue to engage in work, education, transactions, and recreations. People can remain socially connected through technology (Hensley 2020; Tangermann 2020; Kumar 2020).

After the easing of quarantine measures in the Philippines on May 16, 2020, the Department of Health (DOH) issued a strong recommendation to the general public regarding the adoption of social distancing as a preventive measure against the transmission of COVID-19. The DOH emphasized the crucial role of this measure in mitigating the spread of the virus and preventing it from reaching its peak epidemic level within the country (Dela Cruz, 2020). In order to facilitate the transition to a "new normal" environment, the House of Representatives has introduced House Bill No. 6623, which outlines comprehensive guidelines with a specific focus on the implementation and maintenance of social distancing measures (Mercado, 2020; Publico, 2020).

There are fatalities foreseen at a shorter time when social distancing was non-restrictive. Exposure to COVID-19 can surely be accumulated if social distancing is violated. Public local transmissions came as a result of violating social distancing guidelines. Especially during quarantine periods and roll out of vaccines, there had been individuals who flooded some hospitals in Manila just to acquire a vaccine shot for COVID-19.

The proposed system is expected to greatly assist in keeping adequate social distance in crowded environments such as malls, offices, schools, public markets, and other public places. People must be taught how to follow protocols correctly hence for their safety. People in the Philippines should be informed on how to correctly follow protocols such as the importance of social distancing. People can often neglect to observe the regulations, being unaware that this can increase the number of COVID-19 - cases. The goal of this research was to develop a system with the ability to count individuals who are permitted to enter a facility and detect those who are not conforming to the proper social distancing guidelines.

In addition to that, this study may likewise be useful for future references on related literature.

The development of an object detection system for crowd control and monitoring as proposed for this study concerns the ability of the system to calculate individual distances between detected objects. This paper's theoretical framework was derived after extensive research on object detection, image recognition, and distance calculation methods in image recognition. The following existing theories specified served as the backbone and foundation on which this research is based.

Euclidean Distance

In mathematics, Euclidean Distance refers to the distance between two points where the length of the line segment that connects the points should be measured (byjus.com) and is derived through the Pythagorean Theorem. In machine learning modeling, Euclidean Distance is one of the most used distance metrics. It is calculated using the Minkowski Distance formula by setting p’s value to 2 (Sharma, 2020).

Euclidean Distance is one of the four most commonly used distance measures in machine learning (Brownlee, 2020). ArcGIS for instance is a GIS (Geographic Information System) software that utilizes Euclidean Distance in data visualization where Euclidean Distance is utilized as a tool for the software.

Brownlee (2020) added that Euclidean Distance is calculated as the square root of the sum of the squared differences between the two vectors.

- EuclideanDistance = sqrt(sum for i to N (v1[i] – v2[i])^2)

If the distance calculation is to be performed thousands or millions of times, it is common to remove the square root operation in an effort to speed up the calculation. The resulting scores will have the same relative proportions after this modification and can still be used effectively within a machine learning algorithm for finding the most similar examples.

- EuclideanDistance = sum for i to N (v1[i] – v2[i])^2

Moreover, Strand and Nagy (2009) stated that measuring distances on digital grids is essential both in theory and likewise in other applications, and mainly because of its low rotational dependency, the Euclidean Distance is often utilized as a distance function.

Boolean Map Distance

Malmberg et al. (2017) discussed that the boolean map distance (BMD) defines the distance between two images based on the probability of which they are a part of different components after that the image has been threshold by a randomly selected threshold value. This particular concept has been explored and has been proposed as an approximation of another distance function, or the minimum barrier distance (MBD) where the paper proposes to introduce the BMD as a useful distance function.

The study conducted by Malmberg et al. in 2017 titled "Boolean Map Distance: Theory and Efficient Computation" was able to introduce the boolean map distance (BMD), a pseudo-metric that measures the distance between elements based on the possibility that they belong to distinct parts following the thresholding of the image by a randomized set value. In addition to this, Malmberg et al. (2017) were able to summarize available algorithms for computing distance for the discrete BMD and concluded that the Monte Carlo approximation method is not suitable for practical applications given the existence of efficient exact algorithms. In the comparison between exact algorithms, they found that the approach based on Dijkstra's algorithm was faster than the Zhang-Sclaroff algorithm by an order of magnitude for calculating distance transforms on gray-scale images stored using 8-bit pixels. The difference in computing time grows as the color depth increases.

Objectives of the Study

This research aimed to develop a system that would benefit organizations in monitoring crowd control and social distancing, particularly during this pandemic. This study can help people within organizations, businesses, and establishments to prevent the rapid spread of the virus as well as to manage people in accordance with the protocols that are being mandated.

Specifically, this study aimed to attain the following objectives:

1. Develop a social distancing monitoring and recording system using YOLO object detection algorithm that is able to measure person-to-person distance and detect social distancing violations.
2. Create a system to capture video to notify the primary user for the social distancing.
3. Perform software Test for Performance, Accuracy, Efficiency.
4. To perform User Evaluation using ISO standard evaluation tools to target users.

Significance of the Study

The study focused on developing a crowd control and social distancing system for the establishment. Furthermore, the study's findings will be beneficial to people in the following ways:

Managers of various establishments are encouraged to monitor and maintain social distance at their places of business. The system is used by administrators of establishments, who will be the system's principal users, to keep the social distance protocol in check and under control in each of their institutions.

Barangay officials to be able to help with crowd control at occasions or circumstances where the location is anticipated to be overcrowded, such as barangay halls. This study’s technology can be used by barangay officials to keep crowds in line while adhering to social distance protocol at events and gatherings held in barangay halls.

The schools can ensure a safe environment for students by following a safe distance with the support of the system. In comparison to learning at home, schools are essential for providing students with a learning environment. By instructing students to adhere to social distancing protocol, which is watched over by the teacher using the system. This system may offer a safe learning environment for students.

This study may support the Department of Health in its efforts to keep an eye on crowds and prevent the illness from spreading further. In order to maintain crowd control procedures in congested areas and stop the virus from spreading, the data acquired may also be utilized as future references. In pandemic scenarios, the Department of Health may use the study as the foundation for a system of crowd social distancing to slow the virus's rapid spread.

Definition of Terms

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

Angle depression -- downward inclination or deviation from a reference horizontal line or plane; It is commonly used to describe the vertical angle between a line or object and the horizontal plane (byjus.com).

In this study, the "angle depression" referred to the angle at which a camera is tilted downward to capture a subject or scene below the camera position.

CCTV -- Closed Circuit Television a TV system in which signals are not publicly distributed but are monitored, primarily for surveillance and security purposes (Techopedia, 2016).

In this study, the "CCTV" served as a tool in acquiring video footage through its monitoring and recording features.

Counter -- a device or process for indicating a number or amount (Merriam-Webster Dictionary, 2021).

In this study, a "counter" was a system used to count the number of humans in an establishment.

Crowd control -- the control of crowds during athletic events, protests, etc. to avoid conflict (collinsdictionary.com).

In this study, "crowd control" referred to the one of the purposes or desired results targeted to be achieved by this study.

Humans –- bipedal primate mammal; human beings, especially a people as distinguished from an animal or an alien (Merriam-Webster Dictionary,2021).

In this study, "humans" were the main actors or subjects, subjected for monitoring, control, and assessment.

Image recognition -- the ability of software to identify objects, places, people, writing, and actions in images (techtarget.com).

In this study, "image recognition" was used to analyze captured images to determine violators of social or physical distancing.

Social or Physical Distancing -- refers to the practice of maintaining a greater than usual physical distance during a pandemic of a spreading illness, the practice of minimizing exposure to other people or avoiding direct contact with people or things in public places in an attempt to reduce the transmission of infection (Merriam-Webster Dictionary,2021).

In this study, "social or physical distancing" referred to a protocol that is imposed to minimize the transmission of the COVID-19 virus, and it is the major focus and concern in the formulation of this study.

System or Computer System -- a basic, full-featured, and operable system made up of hardware and software which includes all the components necessary to carry out computing operations.

In this study, a "computer system" referred to the system developed for crowd control and monitoring of social/physical distancing.

YOLO -- (You Only Look Once) a single neural network model that directly predicts bounding boxes and class probabilities for objects in an input image (Redmon et al., 2016).

In this study, "YOLO" was the algorithm used for image recognition.

Delimitation of the Study

The study centralized on the main objectives that have been specified for this study. The study revolved around developing a system that captures distance between detected objects and images of social distancing violators with utmost confidentiality where monitoring will be implemented to determine social distancing status that notifies individuals to comply with the social distancing protocol being implemented. The system only limits 25 people to be captured or monitored within an area. A required 90 degrees depression of the camera from the wall to be able to accurately determine the distance.

CHAPTER 2 REVIEW OF RELATED STUDIES

Review of Existing and Related Studies

Mobile-Based Crowd Management System

Shalash et al. (2017) worked on the mobile-based crowd management system, wherein their system consisted of two main parts where the first one was the server-side application connected to IP cameras that was able to detect crowds and the other one was their mobile application on which a different user received an alarm that came from the server-side. This prevents high crowd level danger and also alerts them.

The researchers found out that their IP camera tends to capture images periodically from different locations that were assigned to detect, monitor, and manage crowds then the images were forwarded to the server-side application where images likewise analyzed and the crowd level has been detected through the algorithm. After that, the crowd level indicator marked the location of the image with orange for medium level, red mark for high, and green for low level.

In detecting the crowd, the researchers utilized a texture-based method that required an analysis of image patches compared to other methods. This is to detect the level of crowd and the static crowd situations especially when there are hundreds of individuals in a crowd capturing images, once each person takes up a few pixels, especially those who are far off from the camera. The repetitions in crowds can be captured via Fourier analysis.

The whole system was implemented using C#, SQL, and XAMPP server for their server-side application. For mobile applications, Android Studio and Matlab for crowd level detection algorithms. After logging in, and if there are cases of a very high dense or static crowd, users were able to receive an alarm on their mobile application and whenever he or she clicks it, this redirected them to the map of the location that has been marked with the corresponding color. By that, the user will be notified of the check location. This presents an edge work for swarm level recognition framework in light of versatile application to give a viable strategy to quickly interface and ready all of the framework clients. The early alarm sounds only seconds after the level surpasses as far as possible, bringing about a decent opportunity to take care of issues with the least losses or harm and forestalling high group level risk. Their framework was tried utilizing interface, unit, and ease of using tests ensured that their framework worked likely and their clients responded to it in an effective manner.

The proposed study utilized crowd source techniques that identified the people within the vicinity and captured images from various locations that are to be monitored, analyzed, and to be controlled especially on the crowd on a regular basis. The images were sent to a server and examined to see if they followed the correct social distancing protocol.

Deep Learning based Object Distance Measurement Method for Binocular Stereo Vision Blind Area

In their study, Zhang et al. (2018) presented a novel approach for distance measurement using deep learning and binocular vision. The research aimed to address road accidents caused by hidden or poorly visible obstacles that drivers may struggle to detect promptly. The proposed method utilized deep learning techniques for efficient object detection and recognition.

In the first process, they established a model for binocular stereo vision which was set, and used a Faster-CNN to locate objects in their picture and replace the acquired matching points with a calibrated binocular stereo model for target object spatial coordinates.

In measuring the distance, their detection result of the model of which they acquired through deep learning was used as the focal point of the image planes. Their video collected from a vehicle's camera served as the data to test the positioning capability of the Faster-CNN model. Data sets that were divided into a training set and test sets were collected from dividing videos into six sets in which five frames were extracted every second and saved as jpeg images with the resolution of 800x600 resulting in a total of 2983 images. The images were labeled in XML format containing the image's width, height, and bounding box coordinate.

Physical measurement assessments were executed that authorized the technique given in this paper. Obstructions were captured by binocular cameras from a selection of approaches and distances of which their visual information was fed into a custom target identification system that can promptly differentiate barrier categories and centroid placements. The three-dimensional location of the impediment in space was acquired by amending the associated points and the appropriate camera prognostication matrix in the algorithm. Their distance process can also be used to figure out how far complications and vehicles are apart. Their array between both the binocular camera and the moving barrier was restrained using a moving barrier. The accuracy of a measurement was measured by associating erroneousness with a distance measurement.

Compared to many existing methods, their method was more capable of correctly distinguishing specific objects and calculating their respective distance. It ensured the driver's personal and property protection while driving.

In the current study, the object distance measurement method served as one of the foundations for calculating object distance for the crowd control system.

Convolutional-Neural Network-Based Image Crowd Counting: Review, Categorization, Analysis, and Performance Evaluation

In their paper, Ilyas et al. (2019) presented an observation and analysis of the utilization of Convolutional Neural Networks (CNN) in crowd counting. They highlighted that crowd control involved counting the number of objects, including humans, animals, and cells, through image or video processing techniques such as digital image processing, machine learning, and deep learning. Various approaches, such as detection, regression, and clustering, were employed in crowd control. However, addressing a wide range of crowd features, such as high clustering, varying illumination, varying object density, severe occlusion, and scale variation due to different views, poses a challenge in solving crowd control problems. These crowd features can impact image resolution and disrupt mapping, leading to reduced accuracy.

The authors of these studies investigated and highlighted various techniques, which were categorized as holistic, intermediate, and local approaches for crowd control. Surveys and analyses were carried out in the related research to improve the accuracy of crowd analysis. The CNN model employed convolution, pooling, the Rectified Linear Unit (ReLU), and Fully Connected Layers (FCLs) to accomplish crowd counting and generate density maps. It was demonstrated that CNN-based counting exhibited superior efficiency in terms of accuracy.

Their review of CNN-CC techniques demonstrated the effectiveness in supporting various applications that required adaptive monitoring, identification, and management across diverse crowd-gathering scenarios where such techniques significantly enhanced crowd-management-related tasks in terms of efficiency, capacity, reliability, and safety. Their work presented several key objectives for improving CNN-CC accuracy, including the removal of redundant samples and multitasking (Objective 1), the use of deeper dilated CNN to enhance density map quality (Objective 2), the reduction of computational costs through enhanced counting accuracy via stack pooling (Objective 3), and the increase in counting accuracy of whole-image-CNN-CC through the utilization of semantic and locality-aware features, along with density-level classification (Objective 4). Additionally, adjusting picture sizes helped alleviate challenges associated with high crowd density, making these approaches well-suited for real-time applications.

Real-Time Object Detection, Tracking, and Distances Motion Estimation based on Deep Learning: Application to Smart Mobility

The goal of the study of Chen et al. (2019) was to create a perceptive system that could assist in using the identification of objects and reduce the rate of losses in a real-time system for transportation settings including traffic roads and railway settings. YOLO v3 and SSD algorithms have been utilized for object detection.

To accomplish the objectives outlined in the proposal, they analyzed HOG and DPM approaches in tandem with the distance estimate procedure with the aid of published publications and research.

The results of the study were evaluated, including both road and rail environments, using the You Only Look Once (YOLO)v3 and Single Shot Detector (SSD) algorithms. The Mono Depth technique was used to generate an object distance projection. This model inferred using monocular pictures while being trained on a stereo image dataset. A disparity map was integrated with the object distance estimate as output data. To validate the strategy, the two models were assessed using a variety of backbones, including VGG and ResNet. As the last stage in the procedure, a unique technique based on SSD was developed to assess pedestrian and vehicle behavior by tracking their motions even when no detection was discovered in parts of the images in the series. The SSD method's output bounding boxes were utilized by the researchers to create an algorithm. These researchers developed a well-structured object identification system that takes into account both real-time application constraints and good item recognition accuracy. The two strategies were evaluated in order to determine the optimum object identification method for the application. In this comparison, the YOLO v3 algorithm outperformed the SSD technique.

Real-Time Object Detection of Construction Vehicles: Using Deep Learning Methods

Chadalawada (2020) conducted the research with the aim of identifying a suitable object-detection model for the real-time detection of construction vehicles. This research was motivated by the limited availability of data and research studies specifically focused on object detection for construction vehicles, as compared to regular transportation vehicles.

The study explored various deep learning models commonly used in practice, including OverFeat, VGG16, Faster-CNN, and YOLO. These models differ in terms of their performance and architecture, with variations in layer depth and prediction time. For instance, OverFeat can predict up to eight layers deep, while VGG16 has 16 layers for prediction. Faster-CNN combines accurate deep-layer models with improved speed, and YOLO can capture up to 12 layers deep and predict 45 frames per second.

Among the artificial neural networks discussed in Chadalawada's research, the Convolutional Neural Network (CNN) stands out for its superior performance in image and video recognition, semantic parsing, natural language processing, and paraphrase detection.

Chadalawada (2020) identifies YOLOv3, Tiny-YOLOv3, and Faster R-CNN as the most suitable and efficient deep-learning models for real-time object detection and recognition of scaled construction vehicles using standard datasets. Faster R-CNN demonstrates comparable speed to Solid-state drives (SSD) and Fully Convolutional Network (FCN) models while exhibiting better accuracy. The research also delves into the architectural aspects of these algorithms to gain a deeper understanding of their function.

Monitoring social distancing under various low light conditions with deep learning and a single motionless time of flight camera

Rahim, Maqbool, and Rana (2021) emphasized that low light environments can present challenges in the transmission of diseases due to late-night gatherings by individuals. In such scenarios, the necessity arises for effective methodologies to monitor adherence to safety distance standards, with the objective of preventing further positive cases and maintaining control over the mortality rate. To address this concern, a proposed framework has been introduced that employs the You Only Look Once (YOLO) model for real-time object detection. Furthermore, a social distance measuring approach is implemented using a single motionless Time of Flight (ToF) camera. The computed distance is utilized to assess the risk factor and identify breaches in safety distance.

The researchers employed YOLO, which is a real-time object identification system that adopts a distinct approach to object detection by considering it as a regression problem. YOLO surpasses previous region-based algorithms in terms of speed, operating at 45 frames per second, while simultaneously maintaining a high detection accuracy of 63.4 percent mAP. Unlike most detectors that necessitate multiple GPUs for training with large batch sizes, YOLO's training on a single GPU is relatively slower.

Furthermore, the researchers utilized the ExDARK dataset to fine-tune the object detection model specifically for person detection in various low-light settings. This dataset encompasses both indoor and outdoor high-light photos, along with 10 distinct classes of low-light environments, including ambient, object, strong, twilight, low, weak, screen, window, shadow, and solitary. From the identified objects within these 12 different classes in the dataset, relevant data pertaining to the target class was extracted for training purposes. A custom dataset was employed to evaluate the proposed model. The data was collected from the Rawalpindi market in Pakistan during nighttime amid the COVID-19 pandemic. With an annual urban population growth rate of 3%, Pakistan stands as one of the most urbanized countries in South Asia. The presence of large populations and busy streets renders it a more vulnerable environment for the proliferation of COVID-19, thereby posing significant challenges in maintaining a safe distance in such congested spaces. Consequently, the researchers proposed a deep learning-based approach that utilizes an object detection model to automate the process of monitoring social distance at a fixed camera distance (Cd) under low-light conditions. To strike a balance between speed and accuracy, a static ToF camera was employed in conjunction with the YOLO v4 algorithm to measure social distance at the specified camera distance. These cameras employ light pulses to generate real-time distant views, thereby facilitating easier human monitoring tasks.

The researchers of the study proposed a system for monitoring social distance, which is based on deep learning and utilizes an immobile Time of Flight (ToF) camera. When applied to monitor social distancing at night with the specified camera distance (Cd), the system demonstrates a favorable trade off between speed and accuracy. The precision and accuracy of the system are crucial for achieving the desired outcomes, given its intended real-time application. However, it is important to note that this technique is applicable only within specific settings, and the measurement of individuals' social distance is limited to predetermined Cd values.

In summary, the study presented an effective approach for real-time tracking of social distance in low-light conditions. The proposed system, developed by the researchers, utilized a static ToF camera to observe individuals at a predetermined camera distance and provides measurements in real-world units for monitoring social distance.

Monitoring Social Distancing through Human Detection for Preventing/Reducing COVID Spread

Ansari and Singh (2021) developed a system aimed at tracking and monitoring social distancing among individuals. The research focused on the implementation of an algorithm utilizing object detection techniques, specifically investigating CNN-based object detectors to identify human presence. The algorithm estimated the distance between individuals and provided an output indicating close proximity or a distance smaller than the predefined threshold by marking them with a red indicator.

The study was divided into two main parts: detecting and tracking individuals, and monitoring social distancing among them. The first task involved the use of security cameras to spot and monitor humans. Human detection entailed a two-stage technique that involved locating and classifying objects. The second task focused on monitoring social distancing in public settings, with the algorithm primarily focusing on measuring the distance between individuals.

For the purpose of social distancing monitoring, the study employed CCTV cameras for surveillance, and the video frames captured were processed by the object detection and tracking module. An efficient object detector was implemented using a sliding window-based region approach, where the image was divided into blocks and classified using various machine learning and deep learning techniques. The Non-Maximum Suppression (NMS) algorithm was employed to accurately locate objects within the image. In the second phase, the algorithm performed two main functions: identifying object locations and calculating the Euclidean Distance between pairs of individuals. If the calculated distance was smaller than the predefined value, indicating a violation of social distance requirements, a red mark was displayed on the two detected individuals to alert security personnel.

To train the system, the researchers utilized a dataset consisting of 4146 negative and 2416 positive images from INRIA and Google Colab in Python. Sliding window-based modules were used to evaluate real-time video sequences, with a minimum window size of (64, 128), a step size of approximately (10, 10), and a downscale factor of 1.25. The dataset included static images and encompassed variations of individuals with a resolution of 64 x 128 pixels. With an image size of 264 x 400 x 3, the system processed approximately 567 windows, each measuring 64 x 128 pixels.

Overall, this study proposed a crowd control system for monitoring social distancing through human detection, building upon the concept of preventing or reducing the spread of COVID-19 by enforcing social distancing measures.

NodeMCU Based Social Distancing Alarm Cap

Banda (2021) presented a social distancing alert cap, a wearable NodeMCU device that used NodeMCU with four ultrasonic sensors to determine the distance between two people in four distinct directions. If the persons were in close proximity to one other, the gadget would sound a warning through a buzzer.

The researchers developed a system where the program was loaded and stored in the internal memory of the NodeMCU. Upon powering up, the sensors were activated by sending a 10- microsecond digital pulse to the sensor pins, initiating the sensing process with an ultrasonic wave of 40 kHz. The wave would bounce off the individuals in proximity to the sensor and return to the transmitter.

Using the formula D = V * T, where D represents the distance of the obstacle, V denotes the speed of sound (0.034 cm/microsecond), and T represents the time difference between the transmission and reception of the ultrasonic wave, the program stored in the NodeMCU would calculate the distance of the individuals. If the measured distance was found to be less than 1 meter, a signal would be triggered to alert individuals to maintain adequate distance.

In the proposed study, a notification would be sent to the management when social distancing was not observed until the desired distance between individuals was reached.

Social Distancing Detector Using Deep Learning

Kumar, Patle, and Hirwani (2021) developed a system for determining social distance between people using deep learning and computer vision in order to control the spread of COVID-19. The system was designed to inform users about the importance of maintaining social distance in crowded places. The researchers utilized a pre-recorded video as an input and employed the YOLO v3 algorithm, an open-source object identification pre-trained model, to identify whether people were adhering to social distancing guidelines. Based on the analysis, the researchers created red or green bounding boxes to indicate whether individuals were following social distancing rules. The system was also capable of real-time recognition of people through web cameras, CCTV, and similar devices. This technology proved helpful for authorities in reconfiguring public spaces and implementing preventive measures in high-risk areas. Furthermore, the system's applications extended beyond COVID- 19 control and could be utilized in various sectors, including driverless cars, human activity detection, and crowd analysis.

The study methodology focused on four primary objectives. Firstly, it involved object detection, for which the researchers employed the YOLO algorithm as a transfer learning method and utilized a coco dataset with a specific focus on the person class. Secondly, object tracking was conducted, where each detected person was assigned a unique ID, and a bounding box was drawn around them, representing their center point. The central points of the boxes were measured, and colors were assigned to differentiate between old and new center points. Instances of a new person moving from one point to another were detected by calculating the Euclidean Distance between the old and new center points, with closely located pairs treated as the same person. The study acknowledged the presence of detection errors, as various factors could influence object detection. However, the researchers devised solutions to address these errors and implemented additional features, such as a quadrilateral box to focus solely on the target area or region.

In this study, the methodology opened up new possibilities for monitoring and implementing crowd control measures to minimize the presence and transmission of viruses like COVID-19. Future enhancements to the study could include detecting face masks and body temperatures. The proposed study aims to utilize real-time captured videos as input and employ the YOLO v4 algorithm to detect and analyze social distancing, enabling the labeling of green marks for individuals maintaining proper distance and red marks for those who are in close proximity to others.

Social Distancing Detection with Deep Learning Model

Hou, Baharuddin, Yussof, and Dzulkifly (2020) proposed a technique for detecting social distancing using deep learning in order to estimate the distance between individuals in order to mitigate the effect of the coronavirus pandemic. A pre-recorded video of pedestrians strolling along the street was used to validate the proposed technique. The researchers see the proposed approach as a real-time detection tool in the future, with non-compliant pairings of persons denoted by a red frame and a red line.

Deep CNN methodologies and computer vision techniques were used in their study. To recognize pedestrians in the video frame, an open-source object detection network was first employed. The investigation focused just on the pedestrian class, ignoring all other object kinds. Bounding boxes were developed to enclose each recognized pedestrian, providing the data needed for distance calculation.

A fixed-angle camera took the video frame, which was then converted into a two-dimensional top-down picture to allow for more exact distance calculations. The approach assumed that all of the pedestrians in the video frame were on the same flat plane. A top-down perspective was constructed by picking four points from the frame, allowing the location of each pedestrian to be estimated. The distance between pedestrians can be measured and scaled. Based on the specified minimum distance, distances less than the allowable distance between any two persons were marked with red lines as cautionary warnings. The Python programming language was used to complete the project.

The researchers developed a Deep CNN model as an object detection strategy, treating the detection as a single regression problem to reduce computational complexity. They employed the YOLO model, known for its speed gains and suitability for real-time applications, to detect pedestrians. The YOLO model was trained on the COCO dataset, which included 80 labels and classifications for humans and pedestrians. In this study, only box coordinates, object confidence, and pedestrian object class were used for pedestrian detection. OpenCV's perspective transformation, a straightforward camera calibration approach, was utilized to convert the video frame into a top-down view. This assumption allowed for the calculation of distances between pedestrians, assuming a level and flat plane.

The research findings indicated that the YOLO algorithm, used to identify pedestrians, occasionally misidentified a pedestrian's half-body as an object, resulting in the display of bounding boxes. To address this issue and mitigate detection errors, the researchers implemented a strategy of considering only pedestrians within the designated space when measuring people density. As a result, the accuracy of distance measurements among pedestrians was influenced by the chosen pedestrian identification method.

The study demonstrated that their computer vision techniques could assess the distance between individuals, marking non-compliant pairs of people with a red frame and a red line. The validation using a video of pedestrians walking down a street confirmed the effectiveness of the suggested method in determining social distancing measures in various settings, including offices, restaurants, and schools.

In the current study, the researchers reviewed deep learning models such as the deep CNN approach and computer vision techniques to guide the planning and development of a crowd control system for detecting compliance with social distancing protocols.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

Description of the Proposed Study

This study, in general, is directed to both users and especially to the establishments with the intent to monitor the number of people entering the vicinity and controlling their physical distance from each other in accordance with the implemented proper social distancing protocol set by the government to minimize the impending spread of the Coronavirus Disease (COVID-19), especially with establishments that cater huge crowd of people on a daily basis.

Establishments are now again reopening after a long period of closure from the lockdown that had been imposed, and businesses are starting to welcome and accept limited customers physically while ensuring that the proper protocol mandated by the government is being followed. The focus of the study was to develop a crowd control system for monitoring social distancing protocols that have been implemented in particular establishments. These establishments can utilize the system for computing and monitoring close-range distances of people from each other as they pass or appear within the frame of surveillance cameras. Customers, on the other hand, may be able to maintain their compliance with the distance set between them, and likewise, help the management in preventing and mitigating the risk of possibly spreading the virus. The goal of this study is to measure the accurate distance between individuals within the establishment who have violated the social distancing protocol and control the number of individuals allowed to enter a particular establishment by delivering notifications or alerts to notify the management. In this part of the chapter, the actions done and the sequence, or its order, will be tackled further for the research to be more precise and clearer. The research study will employ a quantitative research methodology.

Methods and Proposed Enhancements

Object Detection

In this paper, object detection was deployed as a method of determining or recognizing objects whereas for this study the subject of interest to be recognized are humans. With the objectives clearly established for this study regarding the development of a crowd control and management system for social distancing, object detection employed the YOLOv4 (You Only Look Once, Version 4) algorithm which is a real-time object detection algorithm capable of detecting and identifying objects from inputs like videos, live feeds, or captured images. The algorithm implements features learned by a deep convolutional neural network (CNN) which is commonly employed in computer vision were using real-world images or videos, the AI automatically captures the features of these inputs to complete a task such as a face recognition and many more. A single neural network was applied to the inputs like an image where it is divided into regions or grids and predicts some numbers of bounding or boundary boxes and probabilities for each region. The boundary boxes are capable of detecting only one subject where every box contains a confidence score based on how accurate the assumptions and predictions are. When compared to the previous YOLO versions 1,2, and 3, version 4 is much more precise and can analyze more frames compared to the previous versions.

Object Distance Measurement

The proposed crowd control and management system for social distancing sought to measure distances between close- range objects or individuals with the intent to implement the mandated physical distance set by the authorities. In machine learning, distance metrics play a pivotal role in machine learning algorithms. There are four types of distance metrics: 1) the Euclidean Distance, the most commonly used distance metric; 2) the Manhattan Distance; 3) the Minkowski Distance; and 4) the Hamming Distance (Pulkit, 2020).

In the conduct of this study, the Euclidean Distance was utilized in measuring object distance. Euclidean Distance simply refers to the distance between two points where in order to find the two points on a plane, they are determined by measuring the length of a segment connecting the two points. The Euclidean Distance formula is derived using the Pythagoras theorem. The Euclidean Distance shall be computed using the bounding box and the centroid information between each detected centroid pair. A default minimum and maximum social distance violation level was set based on the guidelines for social distancing as imposed by the Department of Health and the Inter-Agency Task Force for COVID-19. The bounding box's color upon initialization was green and turned red whenever the maximum distance was violated within the proximity; hence, the color turned back to green when the prescribed distance has been met. A centroid tracking algorithm was likewise applied for tracking those who violated the social distancing level. The displayed information included the number of violators and detected bounding boxes and the distances through the centroids.

Integrating Image or Screen Capture

The study with its main goal of developing a crowd control and management system for social distancing did not only focus on imposing the proper physical distance but also aimed to determine and monitor non-abiding individuals whether they neglect or observe that. With that, the study integrated image or screen capture only for monitoring purposes.

Image capture, also known as machine vision, is a growing field of data acquisition for PCs where it is commonly used for industrial automated inspection systems, applications that include reading bar codes, verifying correct assembly of manufactured parts, and even checking the color of pharmaceutical drugs, and likewise with medical image processing and spectral analysis (Austerlitz, 2003).

This study utilized Python programming language, a widely used general-purpose programming language where it allows a variety of tasks to be performed such as for instance image or screen capture. It provides pyautogui which is a module that can be utilized in taking screenshots. Pyautogui along with NumPy and OpenCV is capable of providing a way to manipulate and save images captured (screenshots). Pyautogui captures pictures as a PIL (Python Image Library) which supports actions such as opening, manipulating, and saving many different image file formats where the image will then be converted to NumPy array for it to be converted from RGB (Red, Green, Blue) to BGR (Blue, Green, Red) because when the image file is read with OpenCV’s imread() function the order of colors are rearranged into BGR (Blue, Green, Red).

Notifications

This study aimed to create a system that not only measures people's distance from an establishment and facilitates crowd control but also notifies the user about violations of social distancing. As a result, this study may incorporate notification, allowing users to be notified if those captured by the system do not follow the social distancing protocol.

In conducting this study, Python as a programming language was utilized, especially its Python notification library, a cross-platform desktop notification library in Python. This library enabled the system to send notifications to the administrator in the form of text appearing on the desktop and inform him about the update or any information gathered. Using said library, it was easier to identify those detected who are not observing proper social distancing.

Components and Design

Software Architecture

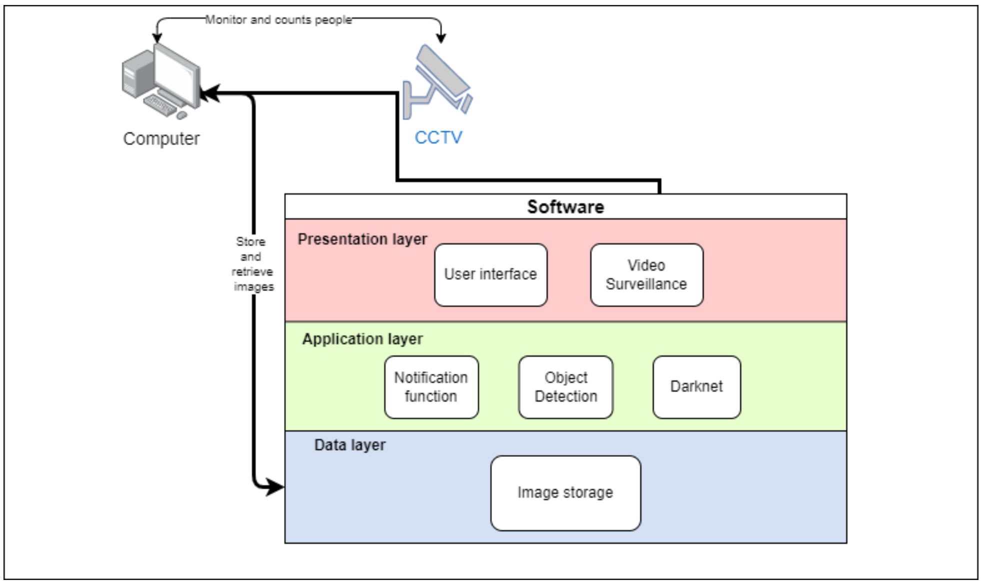


Figure 1. Software Architecture of the Proposed System

Figure 1 shows the Software Architecture of the proposed system. It involves three layers: (1) Presentation Layer - involves the user interface which presents the data and video surveillance; (2) Application Layer-involves the main functions of the system such as notification function, object detection, and darknet; and (3) Data Layer - which involves image storage for managing and retrieval of system data.

System Architecture

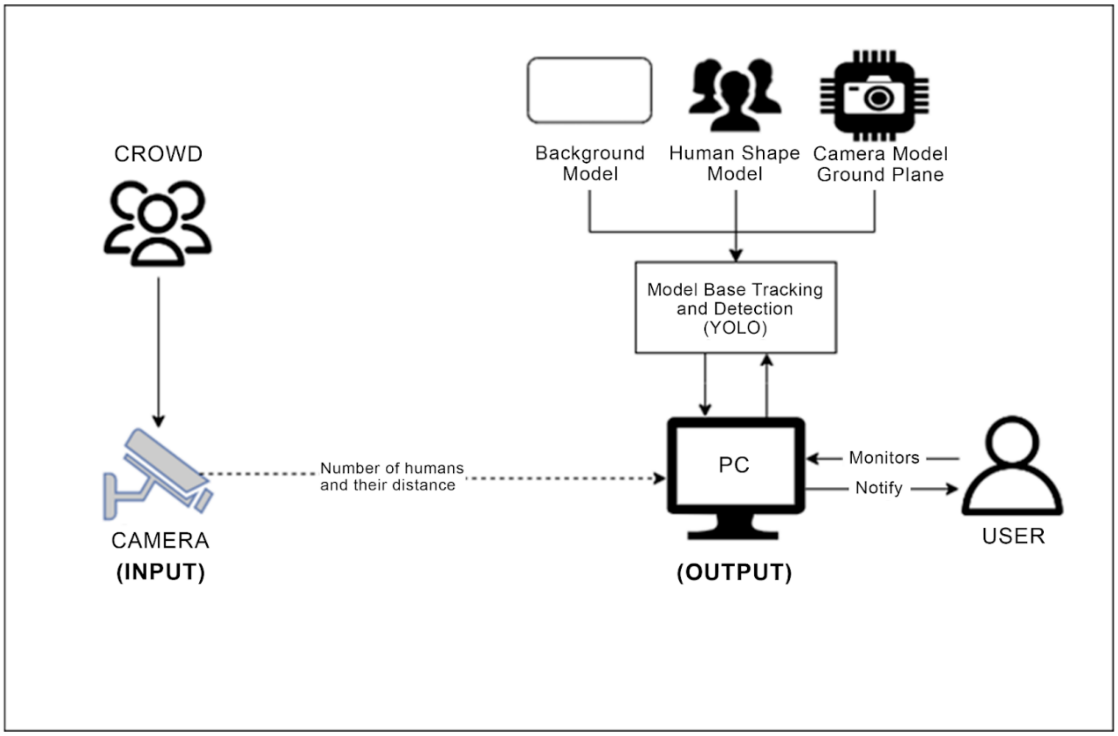


Figure 2. System Architecture of the Proposed System

The System Architecture of the proposed system presented in Figure 2 shows a conceptual illustration of the system with its components. As the CCTV or surveillance camera monitors the people within its vicinity, the system counts the number of humans and calculates their distance. Soon as the system detects violators through the tracking and detection model, the person in charge of the system will notify security.

Procedural and Object-Oriented Design

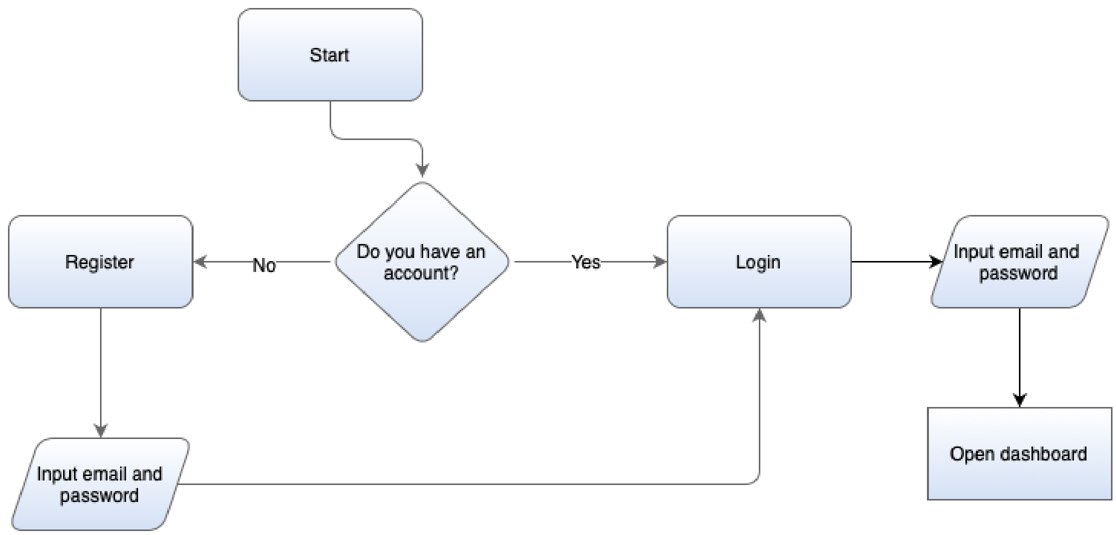
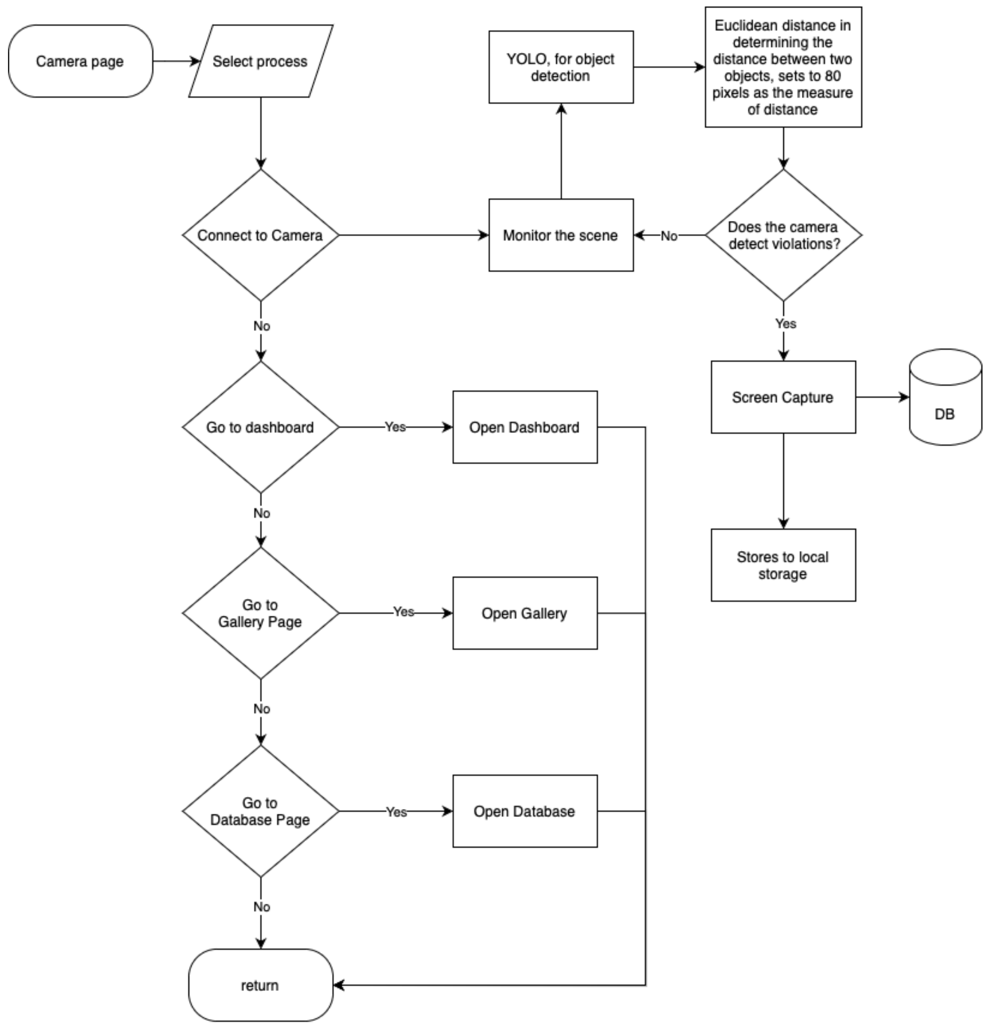
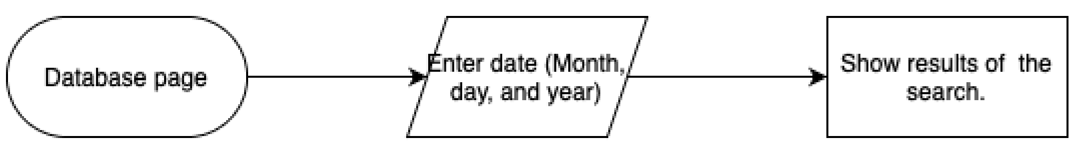


Figure 3. Procedural Design of the Proposed System

The procedural design of the proposed system is shown in Figure 3. The system administrators will first log in into their account if they have one, otherwise they will need to register by using their email address and password. As soon as the person in charge can now enter the system, he or she will be led to the dashboard, wherein the summary of reports, camera, notification, and database are located. The person in charge can connect to the camera and begin monitoring the crowd. If there are any detected violators, the system will capture and save the data to the database, and a report will be generated; otherwise, if there are none, the monitoring will continue. The screen-captured violators' faces will be displayed in the system’s gallery.


Camera page
Select process
YOLO, for object detection
Euclidean distance in determining the distance between two objects, sets to 80 pixels as the measure of distance
Connect to Camera
Monitor the scene
No
Does the camera detect violations?
No
Yes
Screen Capture
DB
Go to dashboard
Yes
Open Dashboard
No
Stores to local storage
Go to Gallery Page
Yes
Open Gallery
No
Go to Database Page
Yes
Open Database
No
return


Database page
Enter date (Month, day, and year)
Show results of the search.

(Cont.)

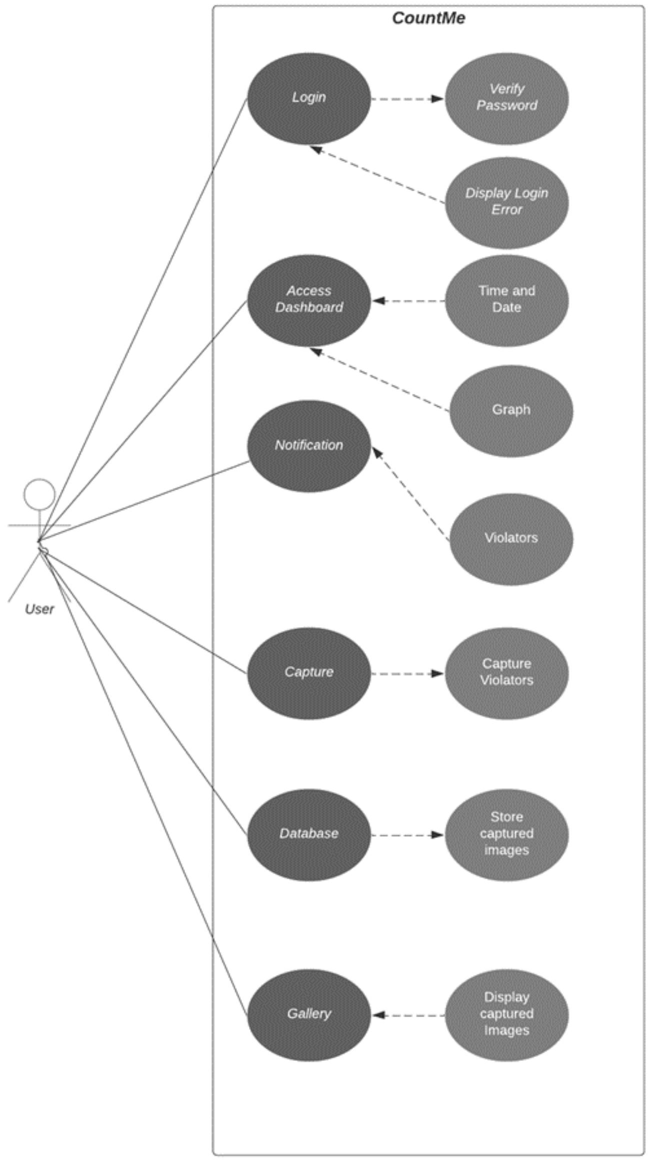


Figure 4. Object-Oriented Design of the Proposed System

This shows how the system monitors and detects violators through the CCTV or surveillance camera.

Methodology

System Development Life Cycle

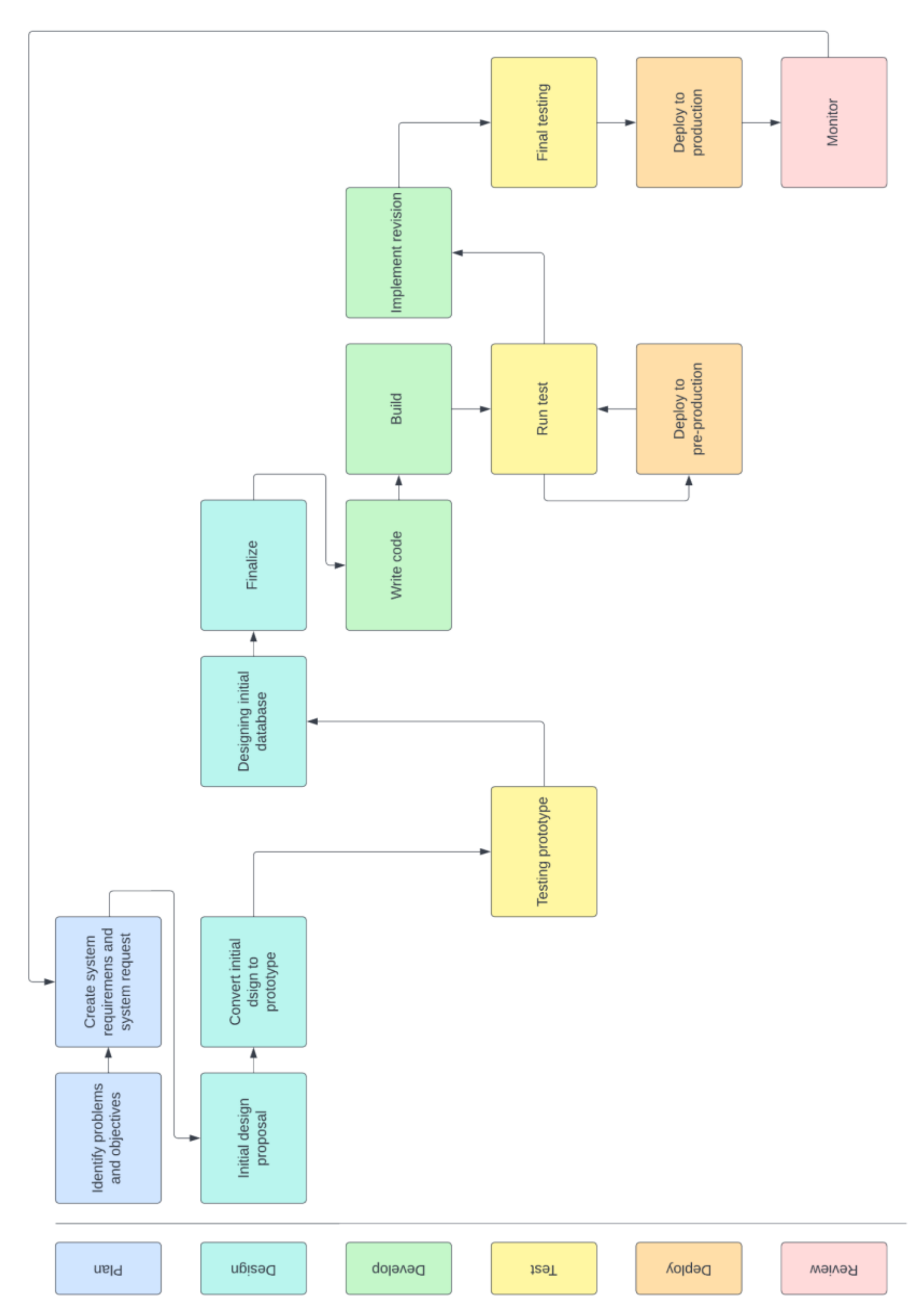


Figure 5. Agile Model of the Proposed System

The development life cycle of the system follows the Agile model. The agile model for this system is composed of planning, designing, developing, testing, deploying, and reviewing.

During the planning phase, researchers identified the problems and objectives, which developed a monitoring system that detects and reports any violations of social distancing. The researchers are still in this phase of creating the system requirements and requests.

In the design phase, researchers designed the initial proposal, converted it into a prototype, and ran a test. In this phase, the initial database design is also being completed and finalized. In the development phase, the finalized design will be put into code and built. This will be run every time the code is built, and a revision will be applied as soon as any changes are detected.

The designed prototype will be coded and tested during the testing phase. The code will be run for final testing as the testing is completed and revisions are implemented.

Since this is in the Agile model, every time the system is run for testing, this will also be a pre-deploy for production until the final revisions are done and ready for final deployment. The review phase involves monitoring the system, and if changes or revisions are made, the process will return to meeting the system's requirements and requests.

CHAPTER 4 RESULTS AND DISCUSSION

Implementation

Hardware and Software Specifications

The system was developed by meeting the software requirements for the system to work. The platform for this system are laptops and computers that run a windows-based operating system. Google Colab is also being used as a development platform. Jupyter Notebook and Visual Studio Code are used for developing the system, uses python as a programming language and MongoDb for its database.

For the system to be fully functional, the hardware specifications must be met. In this study, the researchers utilized a laptop or desktop computer that runs a 64-bit Windows operating system, a surveillance camera, and software and with windows 11th Gen Intel(R) Core(TM) i5-1135G7 processor running at 2.40GHz or 2.42GHz, 8GB of RAM, and Intel(R) Iris(R) Xe Graphics.

System Implementation

The system's implementation intended to test its functionality and accuracy, going through numerous steps to assure its efficacy. This included system design, database setup, coding, and debugging. Many testing and improvements were conducted to enhance the system during this time.

As the system was improved, to achieve accurate findings and optimal system performance, many iterations and versions of the code and graphical user interface (GUI) were employed.

Input and Outputs

This system was designed to monitor the crowd as well as the social distancing within establishments. In order to do this, the user must log in to the system. After logging in, the user will then proceed to the homepage or to the dashboard. For the user to connect its surveillance camera, there will be a feature in the navigation bar enabling your webcam or surveillance camera to connect.

The output of this system is a real-time detection and monitoring of the people inside the establishment. The green and red box around each individual within the camera detects whether there is social distancing performed.

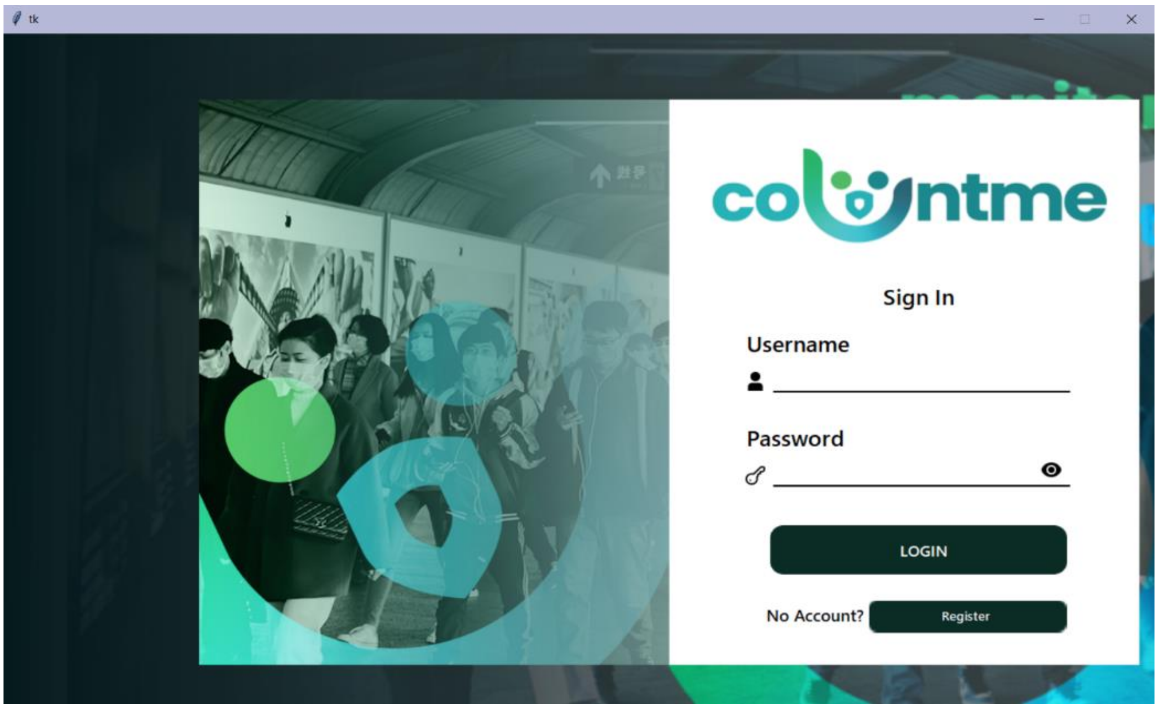


Figure 6. Login page

Figure 6 shows the login page of the system. Users should input the username and password to access the dashboard.

Figure 7. Homepage

Figure 7 shows the homepage of the system after logging in. The navigation bar on the left side contains the dashboard, camera, and notification options.

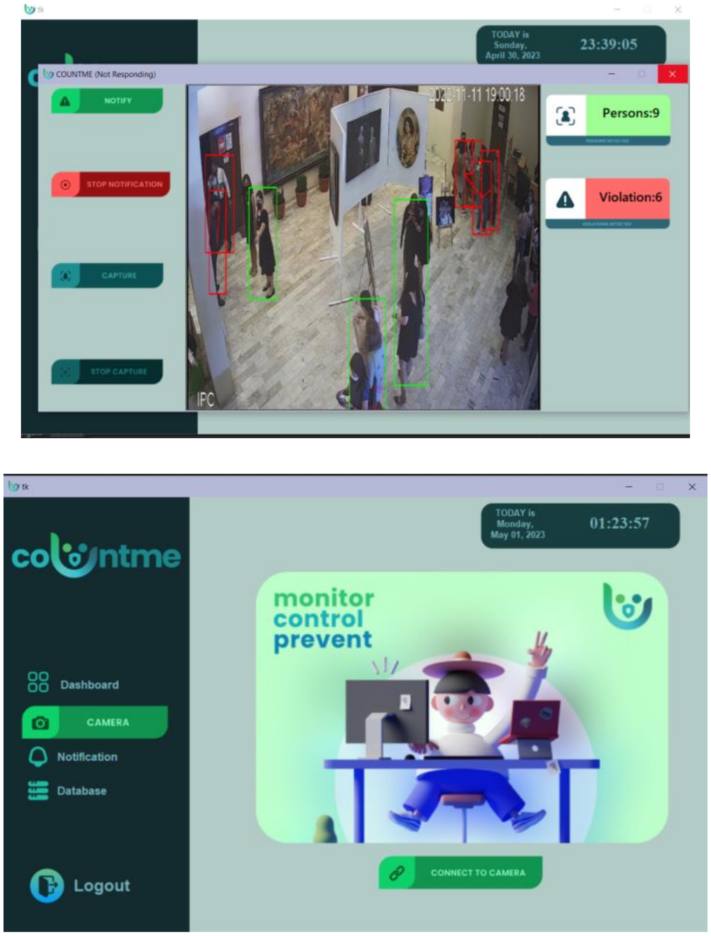


Figure 8. Real-time Crowd Counting and Control Monitoring Dashboard

Figure 8 shows how the camera in the system monitors the crowd using a webcam or surveillance videos. Users can use the camera to monitor individuals inside the establishment. Red boxes around each individual indicate the absence of social distancing while green boxes appear when social distancing is observed.

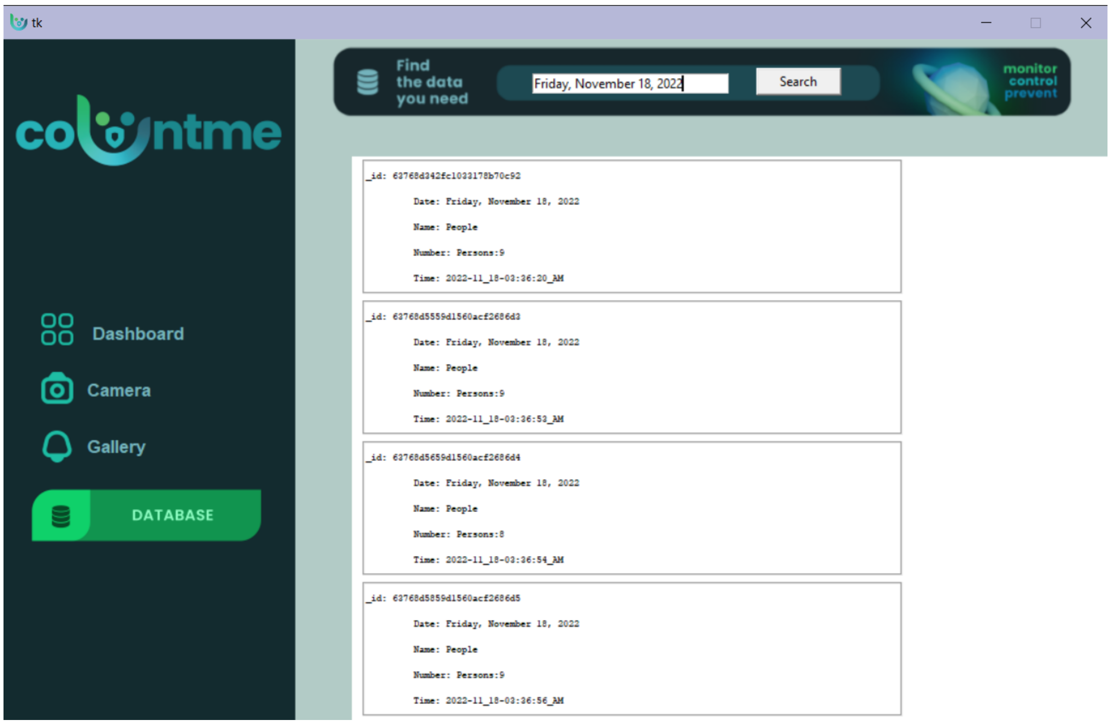


Figure 9. Violator Reports Overview

Figure 9 shows the reports section of the system. This is where the number of humans detected and the date and time the act of violations are caught.

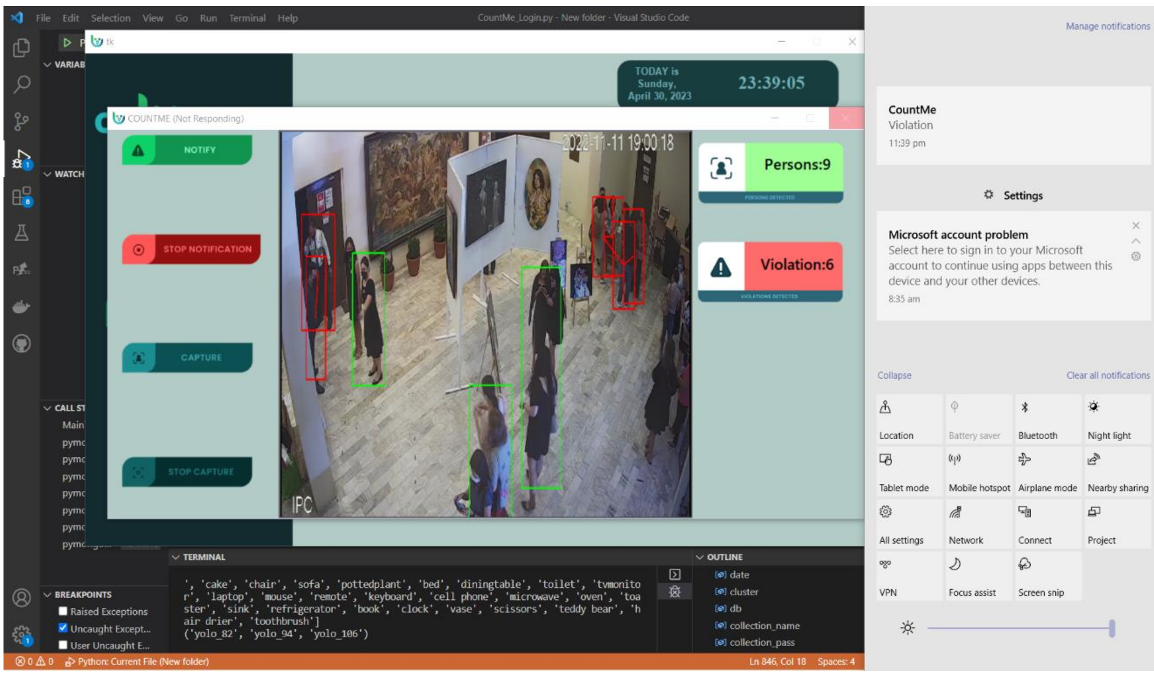


Figure 10. Real-time Violator Detection and Notification

In this figure, the notification section of the system is shown. This is where the notification from the detected violators is displayed.

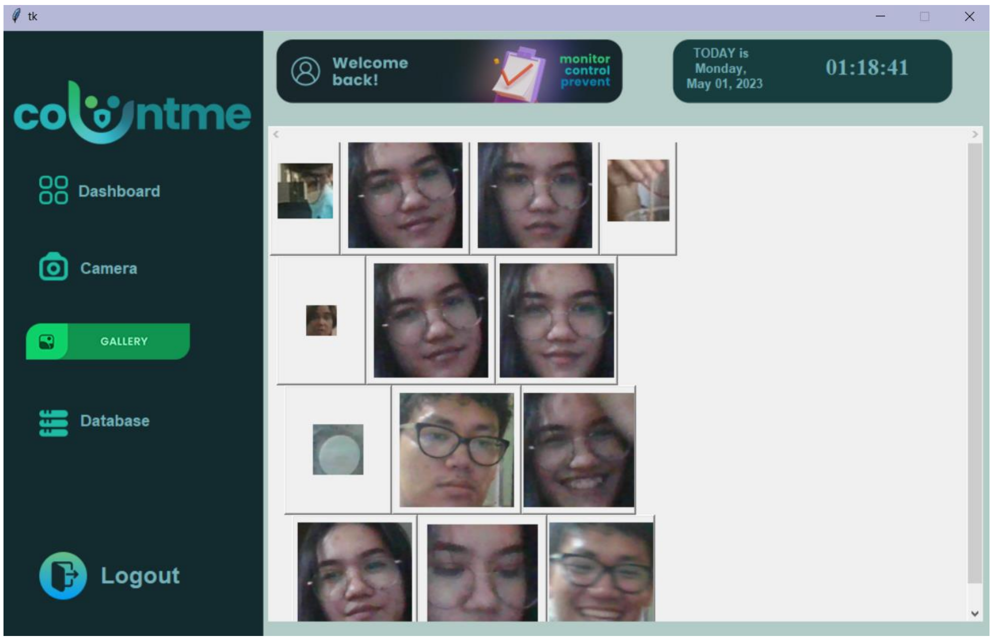


Figure 11. Gallery

Figure 11 shows the gallery of the system. The screen captured images of violators are being displayed based on recent recordings captured.

Results Interpretation and Analysis

The study aimed to develop a system for crowd control management and monitoring for establishments in order to manage and control social distancing protocols that are being implemented to minimize the risk of possible transmission of any diseases or virus such as COVID-19.

The researchers requested CCTV footage from the university’s Management Information Security (MIS) to be used as reference or sample for testing the system. The footage will then be analyzed by the system to determine social distancing violations and to generate reports. For real - time detection demonstration, the researchers opted to utilize DroidCam - an application that is capable of accessing and controlling a phone’s camera, through the system that may act as a surveillance camera in the absence of an actual CCTV camera. With the multiple trials of angles, the 90-degree angle became accurate in capturing the person, and the measurement of person to person does not lessen in 80 pixels based on the recommendation and delimitation of the study.

System Evaluation Results

The system was demonstrated to 30 respondents, including IT specialists, CICT faculty, CAS faculty, administrative officers, and students. A questionnaire or evaluation form was formulated wherein users evaluated the system through prototypes, sample videos, and demonstration of the system.

All eight criteria under ISO 25010 were used for evaluation: 1) Functional Sustainability, 2) Performance Efficiency, 3) Compatibility, 4) Usability, 5) Reliability, 6) Security, 7) Maintainability, and 8) Portability. The questionnaire or evaluation form was composed of 31 statements to determine the quality of the system using a five-point scale: 5 as Excellent (pass); 4 as Good (pass); 3 as Fair (pass); 2 as Needs Improvement (fail); and 1 as Poor (fail).

In addition to this, the scores taken were interpreted using the Likert’s Scale. Table 1 shows the evaluation rating scale.

Table 1

Evaluation Rating Scale

Scale	Descriptive Interpretation
0.01 - 1.00	Poor
1.01 - 2.00	Needs Improvement
2.01 - 3.00	Fair
3.01 - 4.00	Good
4.01 - 5.00	Excellent

Table 2 shows the system evaluation results. The result shows that functional suitability attained a mean score of 4.58 (excellent), performance efficiency attained a mean score of 4.22 (excellent), compatibility attained a mean score of 4.47 (excellent), usability attained a mean score of 4.51 (excellent), reliability attained a mean score of 4.33 (excellent), security attained a mean score of 4.67 (excellent), maintainability attained a mean score of 4.55 (excellent), and portability attained a mean score of 4.58 (excellent). The result showed that the system is excellent based on the descriptive analysis.

Table 2

System Evaluation Results

Criteria	Descriptive Result	Mean
Functional Suitability	Excellent	4.58
Performance Efficiency	Excellent	4.22
Compatibility	Excellent	4.47
Usability	Excellent	4.51
Reliability	Excellent	4.33
Security	Excellent	4.67
Maintainability	Excellent	4.55
Portability	Excellent	4.58

During the course of the evaluation, there were relevant suggestions that have been pointed out, such as generating or displaying reports in the dashboard based on the peak hours or day of an establishment through graphs.

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Proposed Study Design and Implementations

The study aimed at both users and institutions in particular, to monitor the number of people entering the environment and controlling physical distancing according to appropriate social distancing protocols established by the government. With this study implemented, it minimizes the threat especially in facilities that serve large numbers of people every day.

The development of crowd control systems to monitor social distancing protocols in place at specific facilities is of great importance. These devices can use the system to calculate and monitor the proximity of people as they pass or appear within the frame of a surveillance camera. The focus of the research was to develop crowd control systems to monitor social distancing protocols in place at specific facilities. These devices can use the system to calculate and monitor the proximity of people as they pass or appear within the frame of a surveillance camera. Customers, on the other hand, can support controls in adhering to the distances established between them, as well as preventing and mitigating the risk of possible spread of the virus.

Summary of Findings

Based on the collected information by the researchers, a study was formulated that requires social distancing and crowd control in establishments during the pandemic season. The researchers developed a system titled "A Human Counting for Crowd Control and Social Distancing System Using Image Recognition" to identify and count humans inside an establishment and to calculate the distance between them. The researchers utilized the CCTV footage and the DroidCam application for accessing mobile cameras to capture and detect humans in real-time with the use of the YOLO algorithm. Using Euclidean Distance Estimation, the system was able to calculate the distance between humans. The detected faces of humans violating social distancing were captured and these are automatically stored in a database. The generated data will be sent to the administration, showing the number of humans detected and violators. The implementation of this system would be beneficial to the establishments and other applicable scenarios in order to control the number of humans within the area and manage the social distance between them.

Conclusions

After running and evaluating the system, it has been determined that the system successfully carried out its following purpose:

1. Through the application and use of the YOLO object detection algorithm, the system was able to detect social distancing violations and accomplish its primary goal of recognizing and monitoring them. It also has the ability to measure person-to-person distance using the Euclidean Distance to identify violators. In addition, the system has the capability of testing footage obtained from sources that may be used for crowd management and control, along with the notification feature for user error prevention.
2. The system is capable of securing confidential data that can be utilized for monitoring purposes through the real time capture of violator’s face that is automatically stored either through a local storage or in the cloud that is accessible to authorized users.

3. The system successfully performed user evaluation using the ISO 25010 standard to the targeted users through performing various demonstrations and tests using the acquired CCTV footage and real-time detection through accessing a phone’s camera as a substitute in the absence of CCTV cameras.

Recommendations

After performing some testing and improvement on the system, the researchers came up with several recommendations for further studies and improvements.

The researchers would like to suggest the use of a CCTV - for testing the system in real-time that is capable of capturing high-resolution images or footage.

For the system’s functionality, triangulation in geometry was suggested as a relevant topic for further improvements in distance estimation of subjects in order to extract the exact distance between two centroids of the subject from their location to the camera. To maximize subject detection, the researchers recommend simplifying the detection through displaying bounding boxes within the detected head or face of the subject instead of having a bounding box over the body as it limits subject detection if 2 or more subjects stand close with each other.

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Appendices

Appendix A

Letter to the Adviser

February 4, 2022

CYRENEO JR. S. DOFITAS
Associate Professor I
West Visayas State University
Luna St. Lapaz, Iloilo City

Dear Mr. Cyrene Jr. S. Dofitas,

The undersigned are BS Information Technology Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is *"CountMe: A Human Counting for Crowd Control and Social Distancing System using Image Recognition"*

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.Sheina A. Arlanza
2.Jhemer Cris B. Colas
3.Albert Anthony F. Polong
4.J-Anne S. Soliva
5.Charles D. Villafuerte

PS:

Advisers are tasked 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 pass their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

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

Appendix B

Letter to the Intended User/Respondent

November 11, 2022

Dear Users/Respondents:

Good day!

We, (the undersigned) are fourth-year graduating students of West Visayas State University taking up Bachelor of Science in Information Technology presently conducting a study entitled, ***"A Human Counting for Crowd Control and Social Distancing System using Image Recognition"*** as a fulfillment to the requirements for graduation in college.

In this regard, we will be assessing the overall functionality of the system. To successfully carry out this study, we have formulated a system evaluation questionnaire based on the ISO 25010 – Software Product Quality Evaluation. Please supply the needed information to the questionnaire attached with the utmost integrity and do not leave any item/s unanswered. Your full cooperation will be highly appreciated.

Thank You and God Bless!

Respectfully Yours,

SHEINA A. ARLANZA
JHEMER CRIS COLAS
ALBERT ANTHONY F. POLONG
J-ANNE S. SOLIVA
CHARLES D. VILLAFUERTE

Noted:

PROF. CYRENEO F. DOFITAS JR.
Research Adviser

Appendix C

Letter to Conduct the Study

November 15, 2022

MR. JULIUS B. UNDAR
Chief Administrative Officer,
West Visayas State University

Dear Sir Undar:

Good day!

We would like to request from your good office to conduct an assessment of our thesis entitled, ***"A Human Counting for Crowd Control and Social Distancing System using Image Recognition"*** as part of our requirements for thesis in college. We are fourth-year students of West Visayas State University taking up Bachelor of Science in Information Technology.

In this regard, we will be assessing the overall functionality of the system and will be requesting respondents to answer the assessment/questionnaire.

To successfully carry out this study, we the researchers are asking for your permission to utilize and acquire some of the needed **CCTV footage for a duration of three (3) minutes** from the following colleges/offices:

- University Library – Graciano Lopez Jaena Hall
- College of Education
- College of Business and Management
- College of Arts and Sciences
- College of PESCAR
- College of Information & Communications Technology
- College of Medicine
- College of Nursing
- College of Communication
- WVSU Coop

Thank You and God Bless!

Respectfully Yours,

SHEINA A. ARLANZA; JHEMER CRIS COLAS;
ALBERT ANTHONY F. POLONG; J-ANNE S. SOLIVA;
CHARLES D. VILLAFUERTE

Noted:

PROF. CYRENEO F. DOFITAS JR. Research Adviser	DR. REGIN A. CABACAS Thesis Coordinator

Appendix D

Adviser's Endorsement Form

	ADVISER'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F10
		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

Respectfully endorsed to the **Technical Editor**, the attached manuscript of the thesis entitled:

Countme: A Human Counting for Crowd Control and Social Distancing System Using Image Recognition

Said manuscript has been presented to me for preliminary evaluation and guidance, and after a series of corrections/directions given which was implemented by the proponents whose names are listed hereunder and their thorough research, we have come to its completion.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the Technical Editor for **TECHNICAL EDITING.**

Prof. Cyreneo Dofitas
Adviser's Name & Signature

Date: May 22, 2023

Group Members:
1. Sheina A. Arlanza
2. Jhemer Cris B. Colas
3. Albert Anthony F. Polong
4. J-Anne S. Soliva
5. Charles D. Villafuerte

Note: *This form should be accomplished and signed if the corrections and changes made by the adviser have been implemented and a new copy of the document have been printed for checking and submission to the next editor*

Appendix E

Technical Editor's Endorsement Form

	TECHNICAL EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F11
		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

Respectfully endorsed to the **English Editor**, the attached manuscript of the thesis entitled:

Countme: A Human Counting for Crowd Control and Social Distancing System Using Image Recognition

Said manuscript was presented to me and was reviewed and edited in terms of technical specifications, correctness of diagrams and other technical matters. The corrections and suggestions was carried and implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the English Editor/Grammarian for **English Grammar Editing.**

Dr. Ma. Beth S. Concepcion
Technical Editor's Name & Signature

Date: May 25, 2023

Group Members:
1. Sheina A. Arlanza
2. Jhemer Cris B. Colas
3. Albert Anthony F. Polong
4. J-Anne S. Soliva
5. Charles D. Villafuerte

Note: *This form should be accomplished and signed if the corrections and changes made by the Technical Editor have been implemented and a new copy of the document have been printed for checking and submission to the next editor.*

Appendix F

English Editor's Endorsement Form

	ENGLISH EDITOR/GRAMMARIAN'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F12
		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

Respectfully endorsed to the **Thesis Format Editor**, the attached manuscript of the thesis entitled:

CountMe: A Human Counting for Crowd Control and Social Distancing System Using Image Recognition

Said manuscript was presented to me for English grammar editing, corrections has been made and the proponents whose names are listed hereunder implemented said corrections and changes in the revised manuscript.

Now therefore, I hereby **ENDORSE** the said thesis manuscript for **Thesis Format Editing**.

ESPERVAL CEZHAR H. CADIAO
English Editor/Grammarian's Name and Signature

Date: May 26, 2023

Group Members:
1. Sheina A. Arlanza
2. Jhemer Cris B. Colas
3. Albert Anthony F. Polong
4. J-Anne S. Soliva
5. Charles D. Villafuerte

Note: *This form should be accomplished and signed if the corrections and changes made by the English Editor have been implemented and a new copy of the document have been printed for checking and submission to the next editor.*

Appendix G

Certification for Bookbinding

	CERTIFICATION FOR BOOKBINDING (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F14
		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

This certifies that the attached manuscript of the thesis entitled:

Count Me: A Human counting for Crowd Control and Social Distancing System using Image Recognition

Is now ready for bookbinding. Said manuscript was presented to me and has checked the preliminaries, thesis document convention and end matters, made some corrections which was implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** said manuscript for **BOOKBINDING**.

DR. REGIN A. CABACAS
Thesis Coordinator's Name and Signature

Date: June 2, 2023

Group Members:

1. Sheina A. Arlanza
2. Jhemer Cris B. Colas
3. Albert Anthony F. Polong
4. J-Anne S. Soliva
5. Charles D. Villafuerte
6.

Note: *This form should be accomplished and signed if the corrections and changes made by the Thesis Format Editor have been implemented and the four (4) new copies have been printed ready for bookbinding.*

Appendix H

Gantt Chart

NO.	TASK	DURATION	2022											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Planning of the Proposed System	2 months												
2	Project Discussion, Task Dissemination, and System Requirements Identification	4 months												
3	Initial System Development Phase	6 months												
4	Initial Database Design	3 months												
5	Initial User Interface Design	5 months												
6	Initial System Testing	3 months												
7	Final System Development Phase	6 months												
8	Final System Testing	5 months												
9	User Evaluation	2 months												
10	Data Gathering	9 months												
11	Documentation	12 months												

Appendix I

System/Software Evaluation Form for Users

I. PERSONAL INFORMATION SECTION		
Instructions: *Please fill up the necessary information required below.*		
Name(Optional):	Age:	Sex:
Address:	Civil Status:	

II. EVALUATION SECTION	
Instructions: Please evaluate the system/software based on the statements describing specific standards. You may refer to the evaluation rating guide below to better assess the system/software.	
EVALUATION RATING GUIDE Refer to the evaluation rating guide below to better assess the system/software.	
5-(Excellent) **4-**(Good) **3-**(Fair) **2-**(Poor) **1-**(Needs Improvement)	
	RATING

A. FUNCTIONAL SUSTAINABILITY	
A1: Functional Appropriateness • Functions facilitate the accomplishment of specified tasks and objectives.	
A2: Functional Completeness • System covers all the tasks and the specified objectives.	
A3: Functional Correctness • System provides correct results.	
B. PERFORMANCE EFFICIENCY	
B1: Capacity • Maximum limits of a product or system parameter meet requirements.	
B2: Time Behavior • Response and processing times and throughput rates of a product or system, when performing its functions, meet requirements.	

B3: Resource Utilization • Amounts and types of resources used by the system, when performing its function, meet requirements.	
C. COMPATIBILITY	
C1: Co-existence • Perform its required functions efficiently while sharing common environment and resources with other products, without detrimental impact on any other product	
C2: Interoperability • Two or more systems, products or components can exchange information and use the information that has been exchanged.	
D. USABILITY	
D1: Accessibility • System can be accessed by the user	
D2: Appropriateness Recognizability • Users can recognize whether a product or system is appropriate for their needs	

D3: Learnability • The system is easy to learn how to use with effectiveness, efficiency, freedom from risk and satisfaction	
D4: Operability • System is easy to control/operate	
D5: User Error Protection • The system provides protections against errors	
D6: User Interface Aesthetics • User interface enables pleasing and satisfying interaction for the user	

E. RELIABILITY	
E1: Availability • Systems can be accessed and operated in times of need.	
E2: Fault Tolerance	

• system or components operate as intended despite the presence of hardware or software faults.	
E3: Maturity • System, product or component meets needs for reliability under normal operation	
E4: Recoverability • Event of an interruption or a failure, a product or system can recover the data directly affected and re-establish the desired state of the system	
F. SECURITY	
F1: Accountability • Actions of an entity can be traced uniquely to the entity.	
F2: Authenticity • Identity of a subject or resource can be proved to be the one claimed	
F3: Confidentiality • System ensures that data are accessible only to those authorized to have access	
F4: Integrity	

• System prevents unauthorized access to, or modification of, computer programs or data	
F5: Non-repudiation • Actions or events can be proven to have taken place so that events or actions cannot be repudiated later.	
G. MAINTAINABILITY	
G1: Analysability • Effectiveness and efficiency with which it is possible to assess the impact on the system of an intended change to one or more of its parts.	
G2. Modifiability • system can be effectively and efficiently modified without introducing defects or degrading existing system quality.	
G3: Modularity • System or computer program is composed of discrete components such that a change to one component has minimal impact on other components.	

G4: Reusability • An asset can be used in more than one system, or in building other assets.	
G5: Testability • Effectiveness and efficiency with which test criteria can be established for a system and tests can be performed to determine whether those criteria have been met	

H. PORTABILITY	
H1: Adaptability • Systems can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments.	
H2: Installability • System can be successfully installed and/or uninstalled in a specified environment.	

H3: Replaceability • System can replace another specified software product for the same purpose in the same environment.	

EVALUATION FORM ACCOMPLISHED!
I hereby affix my signature below as a gesture and proof of my active participation as a user evaluator of this study; to show that I have assessed and accomplished this evaluation form for users without biases upholding integrity and honesty and based on my abilities, interests, beliefs, and knowledge; without any falsification of my assessment for the motive of accomplishing this questionnaire. _______________________ Signature

Appendix J

Disclaimer

This software project and its corresponding documentation entitled "Countme: A Human Counting for Crowd Control and Social Distancing System Using Image Recognition" 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 Information Technology. It is the product of our own work, except were indicated text.

We hereby grant 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 acknowledge.

Sheina A. Arlanza

Jhemer Cris B. Colas

Albert Anthony F. Polong

J-Anne S. Soliva

Charles D. Villafuerte

June 2023