# ACStalk: Design and Implementation of An Access/Entry Control System using an Internet of Things (IoT) Platform

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## Abstract

An access/entry control system usually consists of many subsystems. These subsystems have different Application Programming Interfaces (APIs), but they need to be integrated and interacted well. Without a good integrated platform, the communications between subsystems will be very complicated. In addition, except user name and password, Radio Frequency Identification (RFID), and the human's biometrics (e.g., fingerprint and face) are used to identify users. Wireless Local Area Network (WLAN), mobile communications (e.g. 4G/5G) and Bluetooth are adopted as the remote access technologies. In addition, with the COVID-19 pandemic, public health and personal safety are getting more concerns. People are required to wear personal protective equipment (PPE) in some special areas (e.g., barns and factories) to ensure the personal healthy and food's safety. To identify the user and detect whether the PPE is correctly worn, this paper proposes an access/entry control system by using an Internet of Things (IoT) platform. Through the proposed IoT system architecture, different identification mechanisms and communication technologies can be adopted, and the messages can be exchanged between two mechanisms. This paper elaborates the architecture design of the IoT platform and discusses the implementation/deployment issues of the PPE detection by using machine learning mechanisms.

**Keywords:** Access/Entry control, IoT, Machine learning, PPE

## 1 Introduction

The COVID-19 pandemic has increased the attention to public health and personal safety. Face masks are now commonplace to prevent virus transmission, and when handling food or livestock, personal protective equipment (PPE) is necessary to safeguard both human and animal health. Proper utilization of PPE not only protects the operator but also ensures food safety and reduces the risk of diseases spreading between humans and animals. However, current entry/access control systems in barns and factories primarily verify employee identity through RFID or biometric recognition, such as fingerprint, iris, and face scanning, with little attention paid to PPE use. An access/entry control system usually consists of many subsystems (or components). For example, in this paper, the access/entry control system includes a personal protective equipment (PPE) checking subsystem, a door lock controller, a reed switch, a monitoring subsystem and a Line notification subsystem. These subsystems have different Application Programming Interfaces (APIs), but they need to be integrated and interacted well. Without a good integrated platform, the communications between subsystems will be very complicated. To address this gap, this paper proposes ACStalk, an access/entry control system that verifies both employee identity and proper PPE usage when entering the work area. In session 2, we will detail the development and implementation of ACStalk.

According to the literature survey, there are many kinds of door lock systems. The authors in [1] propose an intelligent door lock system architecture, analyze the possible threats and propose the corresponding solutions. The user logs into the system for registration and credential verification by using a specific application. The server returns the authentication response to the user. If the login process is successful, the server sends a token to the user. Then, after the user makes an unlock request with the token, the server verify the request. Upon receipt of the request, the server verifies the authorization scope of the user. If the request is within the authorized range, the server forwards the request message to the corresponding micro-controller to unlock the door. In addition, the literature [1] also mentioned the security issues of man-in-the-middle attack and false impersonation attack. When ACStalk authenticates a device, it needs to enter the system and click to confirm before binding, and the network in this article does not open other devices to connect. Thus, the ACStalk system proposed in this paper can avoid the attacks mentioned in [1].

The article [2] proposes a similar architecture as [1]. The users can use tablet computers, smart phones, laptops and mobile devices to lock or unlock the door by using an application developed by the authors. The application provides a login process to prevent illegal usage. If the credentials are invalid, a buzzer alerts and an SMS message is sent to the building manager. In the architecture of document [2], we also found several shortcomings. (1) Bluetooth is a short-range radio access technology and the user should access within the signal range. The proposed system utilizes Wi-Fi instead of Bluetooth to control the system. (2) Arduino UNO is a development version and requires connecting an

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additional Bluetooth module. Running whole system on a micro-controller is not a practical solution. The embedded industrial computer has greater computing power and more interfaces such as USB ports, display interfaces and a Gigabit Ethernet network interface. The proposed system adopts the embedded industrial computer as the hardware. (3) Using a servo motor to lock/unlock the door is not a typical case. The proposed system uses the anode lock and has been deployed in the actual fields. (4) The system performs user login verification before unlocking the door, but the database is located on the external networks. If the network is not available or not stable, the exception events occurs, and the door cannot be opened. The proposed system including the user database is deployed in the local network. Since the local network is more stable and has less exception events than the external networks. The proposed system is not interfered by the problems of the external network. In addition, when the external network is failed, the warning lights notify the on-site management personnel.

The literature [3] proposed a PPE detection and door control system. The authors employ a convolutional neural network (CNN) approach trained on images of workers wearing PPE, including Safety Helmets, Safety Glasses, Safety Mask, and Safety Earmuff. The classification results are divided into 12 categories, namely "Complete", "Didn't use all PPE", "Glasses", "Glasses and Mask", "Helmet", "Helmet and Earmuff", "Helmet, Earmuff and Glasses", "Helmet, Earmuff and Mask", "Helmet and Glasses", "Helmet, Glasses and Mask", "Helmet and Mask", "Mask". Among them, the author did not classify the Earmuffs as a separate category, because the author mentioned in the article that local women would wear veils with the same color as the Earmuffs. The system easily classifies the veil as Earmuffs, so the author classifies Earmuffs with other equipment. The system triggers a red or green light based on the classification result. A red light means "not wearing full PPE" and a green light means "wearing full PPE". Before PPE testing, workers need to wear Safety Shoes. The system has two activation events. If Safety Shoes are detected, the first event is the activation of the RFID reader. The second event is to activate PPE detection when the RFID reader is triggered. However, in the case of its PPE detection, the detection results could cause the system to misclassify when workers wear Safety Glasses. For example, the author mentioned the problem of Safety Glasses. When workers wear Safety Glasses, the system sometimes judges that they are not wearing Safety Glasses. When the worker does not wear Safety Glasses, the system will determine that the worker is wearing Safety Glasses. If there is only a lack of safety glasses, for example, if a worker wears the rest of the equipment but does not wear safety glasses, the system will easily misjudge it as complete PPE equipment. This situation reduces the detection accuracy. The situation encountered here can be solved by using the voting mechanism (to be elaborated in session 3 B.) we also proposed in this paper to add to the system. In the recognition of continuous images, multiple images are used for determination instead of only a single image for determination. In addition, in terms of wearing reminders in the literature, a red or green light only provide information on whether a person is wearing complete equipment. Instead, we go a step further by providing information that alerts you to what PPE is lacking.

The literatures [9] and [10] propose optical solutions. Specifically, the literatures [9] utilizes visible light instead of the physical key to open the door, and the literatures [10] utilizes Quick Response (QR) code scanning to minimize the physical key management issue.

The epidemic in recent years has prompted governments around the world to implement a policy of wearing masks when going out to reduce the risk of virus infection. The authors of the literature [4] propose a method for identifying face masks. It mainly captures faces through OpenCV. The major steps are described as follows. First, the system identifies whether there is a face on the image. If there is a face, then the system checks whether the face is wearing a mask. If there is a mask, it will output the words "wearing a mask" and frame the mask. When the system detects that someone is not wearing a mask, it identifies the person's name and sends an email notification to the person. The proposed system directly notifies the person by using a screen and sound at local. In addition, in terms of personnel identity detection, the proposed system utilizes RFID instead of the face recognition to identify the person. This reduces large efforts of collecting a large amount of face images and training overhead.

ACStalk connects access control related IoT devices, such as RFID readers, anode locks, reed switches and an object detection module developed in this paper. ACStalk identifies the operator through RFID. To exam whether the protective equipment is properly worn, we deploy an IP Cam to retrieve the video from the entrance of the working area. The video is transmitted through RTSP (Real-Time Streaming Protocol) [6] from the IP Cam to a streaming server.

The OpenCV library [7] is used to retrieve the images from the streaming video. The object detection model is developed by using YOLO [8] and detects the objects (e.g., mask and gloves) from the images. Based on the identified objects, ACStalk determines whether the operator correctly wears the required equipment. If yes, the operator can enter the working field. On the contrary, ACStalk will not open the door. ACStalk sends the notification to the manager if the operator tries to enter the working field without correctly dress. The notification can be sent through LINE application or SMS (Short Message Service). This paper also proposes an emergency entry mechanism, where the operator can enter the work area when emergency event occurs. Combining the above functions, ACStalk can not only integrate surrounding hardware devices, but also customize and add different mechanisms according to user needs.

The rest of this paper is organized as follows. In the second session, we will start to introduce the ACStalk platform and the purpose of each component. Next, the third session will explain the system flow of ACStalk and how to use each component. The fourth session will show and explain the experimental results. The fifth session is a summary of the ACStalk system.

## 2 ACStalk Platform

We utilize an experimental field to demonstrate the system model and system operation. The elements of the ACStalk shown in Figure 1 are described as follows. In this environment, there is an inspection area (a) where the detected person needs to stand. The RFID reader (b) retrieves the identity of the tag from the RFID bracelet (g). IP Cam (c) and screen (d) are in front of the inspection area. IP Cam is used to capture the video of the inspection area and sends the video streams to the video server. The detected person can see the video and the detection result on the screen. If the PPE recognition result is pass, the detected person can enter the door by using the RFID bracelet again to unlock the door. The reed switch (e) is used to detect whether the door is open or close. The anode lock (f) is used to unlock/lock the door.

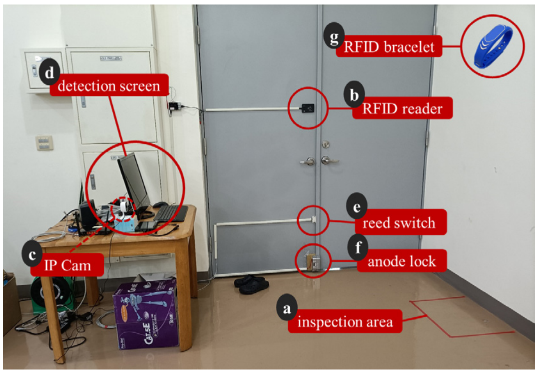



**Figure 1.** Shows the layout of the equipment on the detection site

The elements described above are connected to an ACStalk server. The relationship and operations are elaborated as follows.

### 2.1 ACStalk Functional Block Diagram

ACStalk refers to the architecture of IoTtalk [5] to develop the access/entry control system. The ACStalk server consists of an ACStalk engine and a Graphic User Interface (GUI). The Input Device Feature (IDF) forwards the data obtained from the physical IoT device to the ACStalk engine, and the Output Device Feature (ODF) receives the data of the ACStalk engine to actuate another connected IoT device or program. The ACStalk engine bridges the IDF and ODF data. The GUI is used to connect different IoT devices through graphical interface. The ACStalk server is the core of the whole system and is responsible for integrating the surrounding IoT devices, and each of them is elaborated as follows.

Figure 2 shows the functional block diagram of the ACStalk server. First, the Webview (Figure 2(a)) presents the real-time video, the recognition results, the personnel information and the entry time. The stream server connects to the IP Cam (Figure 2(r)), retrieves the video from the IP Cam and transform the video format by using the OpenCV library. Then the Streaming Server (Figure 2(n)) forwards the transformed video to WebView and the captured image to the Objection Detection model. The Streaming Server transmits the video by RTSP (Real-Time Streaming Protocol).

The Object Detection model (Figure 2(o)) utilizes the recognition model to identify masks, work clothes and gloves, and then sends the recognition results to the ACStalk server. The tag of the RFID bracelet (Figure 2(s)) is used to identify the detected person. Before entering the inspection area, the detected person uses the RFID bracelet to swipe the RFID Reader (Figure 2(p)). This action activates the recognition process. The DoorController (Figure 2(b)) is used for decision whether open the door or not and actuate LINE notification. The decision returns three different results according to its rules. The results include (1) emergency entry state; (2) unequipped state; (3) correct wearing state. The DoorLock (Figure 2(c)) receives the decision command and unlock the door based on the command. The administrator uses a mobile device to receive LINE notifications (Figure 2(d)). The reed switch (Figure 2(q)) detects the events of the door open and close.

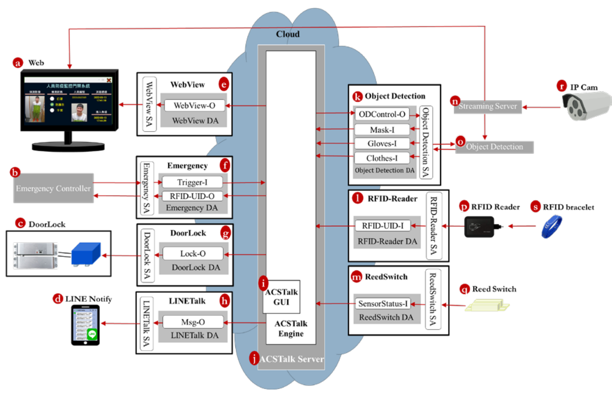



**Figure 2.** ACStalk functional diagram

### 2.2 Device Models and Device Features

The device models designed in this paper consist of seven software modules (Figure 2(e)~(h), (k)~(m)). The device models connect the IoT devices to the ACStalk server. Each device model is constructed by the SA (Sensor & Actuator Application) and DA (Device Application). The SA deals with the interaction with the sensor, while the DA communicates with the ACStalk server. For example, the RFID-Reader SA is used to obtain the UID (User Identifier) value from the RFID Reader device (Figure 2(p)).

The UID is obtained after the detected person swipes the RFID bracelet. Finally, the UID value is transmitted to the ACStalk server through the RFID-Reader DA. Each DA contains a single or several DFs (Device Features), and its main function is to interact with the ACStalk engine.

### 2.3 ACStalk GUI

Figure 3 presents the relationship information between different models in the ACStalk GUI. The GUI is a web-based interface. Figure 3(a)~(i) are individual DMs (Device Models). Each DM contains a single or multiple DFs (Device Features). Figure 3(a)~(d) on the left are the input DFs, and Figure 3(e)~(i) on the right are the output DFs. Each input DF connects to one or more output DFs. Each set of connecting lines are formed by connecting two segments with a connecting circle (i.e. Join) in the middle. Each sensing device or software can exchange information through the connection on the GUI.

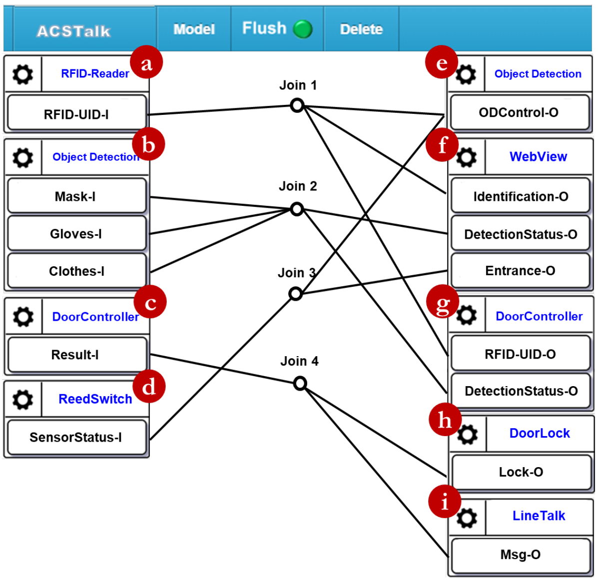



**Figure 3.** ACStalk GUI

The following description utilizes Join as the classification to explain different functions. Upon receipt the UID (i.e. RFID-UID-I) from the RFID reader (Figure 3(a)), Join1 sends the UID to Object Detection module (i.e. ODControl-O, Figure 3(e)), WebView module (i.e. Identification-O, Figure 3(f)), and DoorController module (i.e. RFID-UID-O, Figure 3(g)). The UID is a signal to notify the Object Detection module to activate the identification process. The identification process checks whether the detected person wears the mask, gloves and working clothes. The identification results (i.e., Mask-I, Gloves-I and Clothes-I, Figure 3(b)) are sent to WebView (i.e. DetectionStatus-O, Figure 3(f)) and DoorController (i.e. DetectionStatus-O, Figure 3(g)) through Join 2. The DoorController verifies the UID, checks whether the PPE is correctly worn (to be elaborated in session 4), and then sends the result (i.e. Result-I) to the DoorLock and LinkTalk through Join 4. If the result is an emergency entry event or a correct wearing event, the door is opened. Otherwise, a warning message is sent to the manager through LINETalk.

When a person opens the door, ReedSwitch (i.e. SensorStatus-I, Figure 3(d))] pushes a signal to Object Detection module and WebView module through Join3. This signal notifies that the door is opened. Upon receipt of the UID, identification results and door status (i.e., open or close), the WebView retrieves the personal information from the database and display the person's identification, the entrance time, PPE information and door status on the WebView.

# 3 System Architecture Design and System Development

The system in this article is used to check whether the user's PPE equipment is complete, and if the system checks are complete, the test can be passed. The detection is matched with door lock control, and it can only be unlocked with qualified PPE equipment, otherwise an alarm notification will be sent to the management personnel. First, the user must first use the RFID bracelet to approach the RFID reader for identification. At this time, the display screen will display the user's personnel information. Next, the user must stand in the detection area. The display screen will not only display the real-time image of the person but also the equipment check result. Personnel will wait for that person's equipment option to be checked during the system check. If all the equipment is checked, it means that the system determines that the personnel have worn all the equipment. At this time, you can put the RFID bracelet close to the RFID reader again to trigger the unlocking of the door lock. If the detection fails, even if the RFID reader is sensed again, the door cannot be unlocked. The above chapter 2 mentions that ACStalk is the core of the whole system, which is mainly responsible for the integration of peripheral sensing elements, the triggering of the recognition program, and the presentation of web data. The work each component is responsible for is described below.

## 3.1 Sensors

The sensors used in the system in this paper include RFID bracelets, RFID Readers, anode locks, and reed switches. The RFID bracelet contains RFID tags and is used with RFID Reader. The method of use is to actively approach the RFID Reader through the RFID tag. At this time, the MPU will use the HID Code to parse the RFID tag returned by the USB RFID Reader interface. In addition to being used to identify people, the RFID sensing module is also used to trigger the process of starting the identification program. This method of triggering the identification program to run can achieve the purpose of energy saving, and secondly, it can also reduce the streaming delay, thereby reducing the burden on system performance. In addition, there are two stages to sense the RFID Reader. The first sensing includes the identification of the person and triggers the operation of the identification program. The second sensing is as a trigger to open the door basis after the person passes the detection. This sensing will be combined with the identification result to decide whether to unlock or not. Additionally, there is a way to trigger the door to open in exceptional circumstances.

At the beginning of the system design, it was considered that if the operator needs to quickly enter due to an emergency, the user can utilize the RFID bracelet to continuously sense the RFID reader 3 times within 10 seconds without wearing complete equipment to trigger the emergency unlocking process. If the door is not manually opened within 3 seconds after unlocking, the door lock will automatically lock. The door locks used in this system are anode locks. In the case of following the normal identification equipment process, the anode lock will passively trigger whether to unlock according to the identification result and the second induction of RFID bracelet. The emergency unlocking procedure used in emergency situations triggers the unlocking of the anode lock by continuous sensing. After the door lock is unlocked, the user can open the door and enter the working area. At this time, if the user opens the door and enters the work area, the program of the recognition program will be stopped, and the time when the user enters the work area will also be recorded. In addition, the receiving and sending of the sensors is performed through the MPU, and the programs of these sensing components are set to automatically execute after startup, making the system operation and maintenance easier.

### 3.2 Identification Process

This system uses YOLO to identify whether personnel wear equipment according to regulations. There are three major objects to recognize: (1) masks (2) gloves (3) work clothes. In the model construction, the OpenCV library will be used to collect IP Cam images transmitted by RTSP, and 1,098 images will be pre-collected as a training set. There are three labels, namely masks, gloves and work clothes. Use the labeling tool to label each image in turn and build a model through 6000 training sessions. The above three labels (a) masks, (b) gloves, (c) work clothes can be found in Figure 4. The model trained here is called model 1. According to the model identification results (as explained in session 4), we found that using the mask label method [See Figure 5(a)] of model 1 cannot confirm whether a person is wearing a mask correctly but can only identify whether a person is wearing a mask. According to the principle of epidemic prevention measures, personnel must wear masks correctly. To comply with the requirements of epidemic prevention, follow-up experiments re-examined the labeling issue. The system must not only be able to identify whether a person is wearing a mask, but also be able to identify whether a person is wearing a mask correctly in accordance with regulations. The correct way to wear it is to cover the mask from the bridge of the nose to the chin. This revision experiment redefines the scope of the border on the label and the category of the label in response to this requirement, that is, not only the mask worn by the person is marked, but the face of the person wearing the mask is marked. Among them, a new training data set was collected, with a total of 957 images, and the number of labels was divided into four categories: (1) face wearing masks correctly [see Figure 5(b)], (2) face not wearing masks correctly [see Figure 5(c), Figure 5(d)], (3) gloves and (4) work clothes.

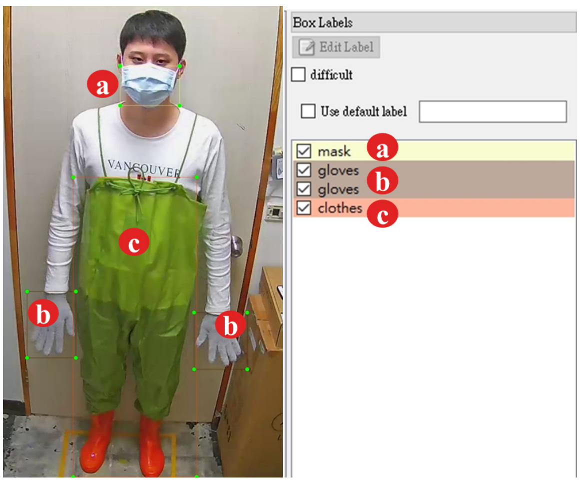



**Figure 4.** The labeled data includes (a) mask, (b) gloves and (c) work clothes

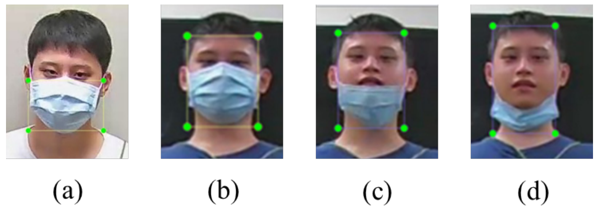



**Figure 5.** Labels of Model-1 and Model-2

The labeling method for gloves and coveralls remains the same here. After retraining, another model can be obtained called model 2. Figure 5 Displays the label range of model 1 and the label range of model 2. (a) is the model 1 labeling method. (b)(c)(d) are model 2 labeling methods. Among them, the label category of model 2 is further divided into correctly wearing a mask and not correctly wearing a mask. Here (a) is the label data of model 1, which only labels the mask worn on the face. (b)(c)(d) is the label data of model 2, which mainly marks the faces wearing masks. This data is further broken down into three ways of wearing, (b) extend the mask to fully cover your nose, mouth, and chin. (c) wear the mask below his nose or mouth. (d) push his mask under his chin.

In addition, this paper adds a voting mechanism to the identification, as the name suggests, it uses a majority vote to decide the result. During the recognition process, the system must recognize at least 3 out of 5 consecutive recognitions before the system can determine the existence of the object. If it does not exceed 3 times, recalculate until the above conditions are met. This mechanism can also greatly improve the stability of the system.

### 3.3 Display Screen (UI)

The ACStalk system builds a web-based service architecture (Figure 7(a)~(e)) for the industry to use. Its interface design includes real-time video streaming (Figure 6(a)), check results of equipment identification (Figure 6(b)), personnel information (Figure 6(c)), recording the time of entering the inspection channel (Figure 6(d)) and recording the time of entering the work area (Figure 6(e)). The real-time video streaming (a) is transmitted from the IP Cam by using RTSP. The video is captured and transformed into Base64-coded data by using OpenCV library in this system. Note that the Base64-encoded data can be displayed on the web browser such as Chrome, IE and Firefox. Then the Based64-encoded data is transmitted to the Webview on the web browser through the WebSocket protocol by using a python suite Flask. The information of the check result of equipment identification (b), personnel information (c), record time of entering the inspection channel (d) and record time of entering the work area (e) are retrieved from ACStalk by using JavaScript.

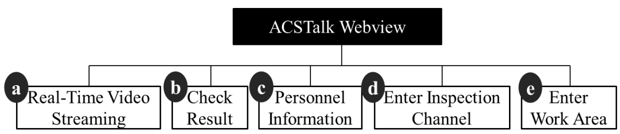



**Figure 6.** The structure of ACStalk web interface

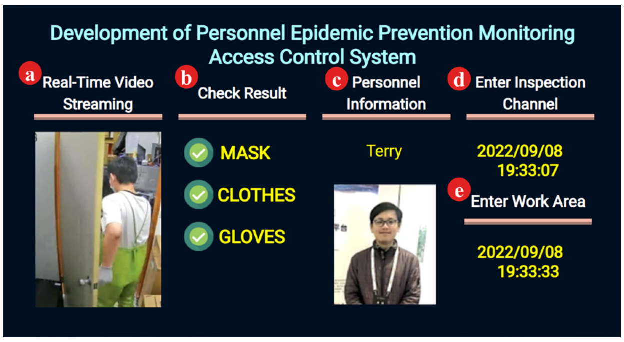



**Figure 7.** ACStalk Webview

The result shows whether there are ticked equipment items. The ticked equipment items indicate that the equipment worn by the user has equipment items that have passed the system checking. Personnel information will display the personnel information corresponding to the RFID tag on the webpage. Enter Inspection Channel and Enter Work Area are when the user interacts with the system to trigger the operation of the sensor, and then the system reads the sensor and returns the time for personnel to enter and exit the inspection area.

## 4 The Experiment Results

In this paper, we propose two machine-learning models. Model 1 identifies the mask, gloves and working clothes. Model 1 is widely used to identify the objects that we train in this paper. However, in the real world, the Model 1 will recognize the mask regardless of whether it is worn correctly or not. While using Model 1, we should add the additional procedures to check whether the mask is worn well. Model 2 is an improved version of Model 1, which can recognize whether gloves, clothes and masks are worn correctly. To evaluate the performance of Model 1 and Model 2, we use 759 images where the masks are correctly worn in 186 images and the masks are not well worn in the rest 573 images.

For identifying all objects such as the mask, the gloves and the working clothes, Model 1 and Mode 2 successfully identify 650 and 686 images, respectively. The accuracy rates are 85.6% and 90.4%, respectively.

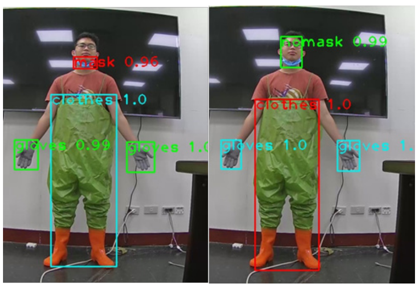
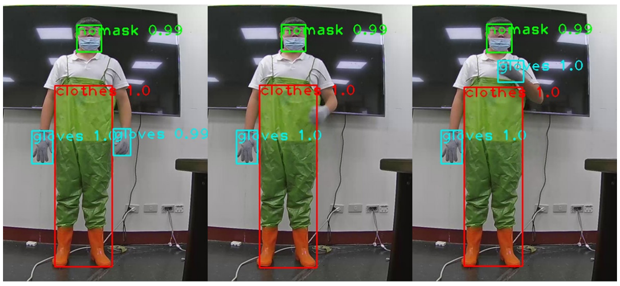


**Figure 8.** Masks are recognized by Model 1 and Model 2

Figure 8 shows the results that the masks are recognized by Model 1 (left) and Model 2 (right). The masks are not correctly worn in these images. We can observe that Model 2 can identify that the mask is not well worn, but Model 1 still identify the mask. We further analyzed the recognition results of whether the mask is well worn or not. Model 1 only correctly recognizes 186 images (24.5%) and Model 2 successfully recognizes 715 images (94.2%). Among the images misidentified by Model 1, 502 images are not correctly wearing a mask but are misjudged as wearing a mask, and another 71 images are not recognized as wearing a mask. Among the images misidentified by Model 2, only 44 images are not recognized as wearing a mask. In these 44 images, there are 42 images where the masks are not correctly worn. Therefore, there are only 2 images misjudged by Model 2 and the accuracy of Model 2 is up to 99.7%.

We find another issue in the real cases. When people stand at the inspection area (Figure 1(a)), the gloves may be unrecognizable due to hand's wobbling. We further discuss these unrecognized images. Figure 9 shows the images that are continuously captured. We observe that one is not recognized in (b) due to the hand's part is blurred, but two gloves are recognized in both (a) and (c). A typical IP Cam take 25~30 images per second. We propose a majority voting method where we take the recognition results of several images into account. For example, in Figure 9, two images identify the gloves and one image only identifies one glove. The system will determine that both gloves exist. In our implementation, ACStalk takes 5 images for inference.



(a) (b) (c)

**Figure 9.** Recognition results of continuously captured images

## 5 Conclusion

Based on the technology of the Internet of Things and YOLO, we have developed the identification program in the ACStalk platform to detect whether the person is wearing equipment as required, and the decision of the detection result is combined with the door lock module to trigger the door to open. This paper details the differences between ACStalk and other literatures, and we display the video stream, detection results, and sensor triggers on the web page one after another. Users can also watch remotely through different platforms. The system of this paper is also combined with LINE notification, so that users can receive abnormal status messages at the first time for proper handling. The major contributions of this paper include three items. First, we develop an IoT-based platform to integrated personal protective equipment (PPE) checking, a door lock controller, a reed switch, a monitoring subsystem and a Line notification subsystem. Second, in the identification process, we show that different labeling methods (i.e., Model-1 and Model-2) have different results, and better labeling method provides higher accuracy. Third, in the actual deployment, the human body will shake while identification process, and we added a voting mechanism to solve this issue. In addition, during the experiment, we also found that the labeling methods of model 1 and model 2 also lead to different results. If the object to be identified is like a mask that contains more than two states (correctly worn and incorrectly worn), it is necessary to extend the scope of a single tag to, in addition to the object itself, add the area around the object that can assist in object identification, so that the system can identify the wearing of the mask. For example, there are safety concerns if the mask is worn backwards or the chin strap is not worn on the mask. At this point, the method proposed in this paper can be used to label the range containing the face and the helmet to train the system to identify whether the helmet is worn correctly. From the experimental results of this paper. Take wearing a mask correctly as an example. If the model is trained only with the mask as a marker, the mask can indeed be identified, but it is impossible to confirm whether the person is wearing the mask correctly. Using the entire face with a mask as a mark to train the model can clearly determine whether the person is wearing the mask correctly, and the recognition rate is as high as 90.4%. In the future ACStalk can adjust our model according to different scenarios instead of just identifying masks, work clothes and gloves. For example, the entry and exit of the clean room in the factory requires complete wearing of dust-free clothes, dust-free caps, dust-free gloves and dust-free shoes. Through such an application, our ACStalk will become more flexible.

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## Biographies

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