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IOT Real-Time People Counting Using Raspberry PI (IOT-RepCO)

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Abstract. IOT - RepCO is a People Counting System that allows tracking and verification activities to be systematically carried out. This web-based system ensures that the accuracy and reliability of the information sent by the service provider company by changing the manual way to the online system. In addition, this system also allows information to be stored in digital form which indirectly creates a "paperless" environment. Security features are also enhanced by using IOT - RepCO. Python and OpenCV languages are used in the development of this system. While "ubidots" are used for data storage in "cloud". The requirement for this solution were carried out in Datasonic Corporation Sdn. Bhd. whereby it also provides a testing ground and verification of the system. The diversity of users in this system requires user-friendly interface design as well as minimal navigation and low fidelity concept as an appeal for all users who will use the IOT - RepCO system. It is hoped that the construction of the IOT - RepCO system will assist the companies as well as other parties such as fire department during the emergency evacuation such that it indirectly improve the quality of service to the customers as well as providing an important information during evacuation process.

1. Introduction

Real time people counting system has been implemented in several areas where activity of people is monitored and analysed [3]. There are various ways of counting people in the markets and making this shift from existing solutions to count people in buildings offers a variety of markets where this kind of device would be useful. Several systems have been developed for these purposes [1][2][3][5][12]. A study was carried out to count people during evacuation based on the existing work process. Recently, many systems using a wireless sensor network and mobile nodes are applied to all industry area (e.g. military, monitoring for protection of an ecosystem, distribution, factory automation and so on) [4][7][8]. One of the most obvious is to make it easy for security teams to determine if there are people left after hours in the building [9][10][11]. In this case, the requirements are very similar to those of emergency responders in the same way they require the same information. Therefore, in both scenarios, the same device can be designed for application.

2. Related works

Several systems for counting and tracking moving people been proposed using various technology [1][2][3][5][11][12]. To process image data, these systems were based on motion analysis of moving people. Various technologies been used for the detection and counting such as using fixed video camera

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and computer visions [1[[2][3][9], stereo images [5], infrared beans, thermal counters, and wi-fi counters [12]. The considerations on using these solutions were mainly depends on its usage and accuracy which also propagate linearly with the implementation costs. V-Count is a retail analytics technology provider intended to drive business growth by tracking customers in physical locations through visitor analytics [10]. FootfallCam is a British company, started by a team of experienced engineers with the vision of creating the most advanced people counting system in the market. Through years of research and development, FootfallCam has developed a technologically sophisticated system with many world-first innovations [11]. Most of these commercial systems can give a good reading in terms of accuracy of detection and provide an extensive functionality in reporting. However, the trade-offs between these solutions were the cost and unnecessary functions.

3. Case Study

A corporation company based in Kuala Lumpur with more than 200 employees has been selected for our case study specifically for the requirement and testing. In the event of emergency at this company, the local emergency responder may order to evacuate premises. After an evacuation, it is critical to get the accurate number of employees and visitor who are currently present in the building. Provided with an empty sheet of paper, employees and visitors are counted manually and the total number of employees and visitor who are present and absent are filled in. Figure 1 shows a process flow during fire notification and response and Figure 2 outline the sample of evacuation attendance checklist form. This will take a lot of effort and time to ensure that number of head count is accurate. Thus, this will cause rescue process to be delayed. Problems faced by emergency responder and safety manager were identified including:

- No automated people counting system in or out of premise.
- Manual counting might not be accurate and consume time.
- Safety Manager is facing difficulty to determine whether employees are absent or present in the field.
- The name of employee or visitor need to be filled manually and this will take a lot of effort and time in order to do so.
- Difficulty to retrieve the number of total headcounts in and out of premise.
- Required a lot of resources.

This project is aimed to solve these problems due to current people counting devices are not designed with this use case in mind although they are easy to use and accurate. Furthermore, the output data provided in such a way that they are not suitable for rescue teams. While the impediment with manual reconciliation is the accuracy of the baseline are depending directly on the accuracy of attendance systems. Thus, making it unsuitable for public area such as malls and shop as it consumes valuable response time. On the other hand, the impact of reconciliation error is there are possibilities that wrong counting of people who are already safe as “trapped” or wrongly counting someone as “not trapped” and which will lead to wasted valuable resources used for searching people.

3.1 IOT-RepCO Design and Implementation

Computer vision requires the processor to receive a live image input. Since this project uses a Raspberry Pi, hence it is possible to use USB webcam as the device input. Thus, the design is simplified for easier integration of USB with Raspberry Pi. The camera can be mounted on the ceiling near the door perpendicularly down to record people movements in and out of the room.

The sequence in which the software will be executing in order to detect people are as follows:

a. Images are captured by camera frame by frame (Capture camera frame images by frame)
b. Frames are passed through algorithms for object recognition from OpenCV
c. Movements of the objects are tracked across the view field.
d. Object's motion direction is determined
e. Net movement counts are updated based on the movement direction.

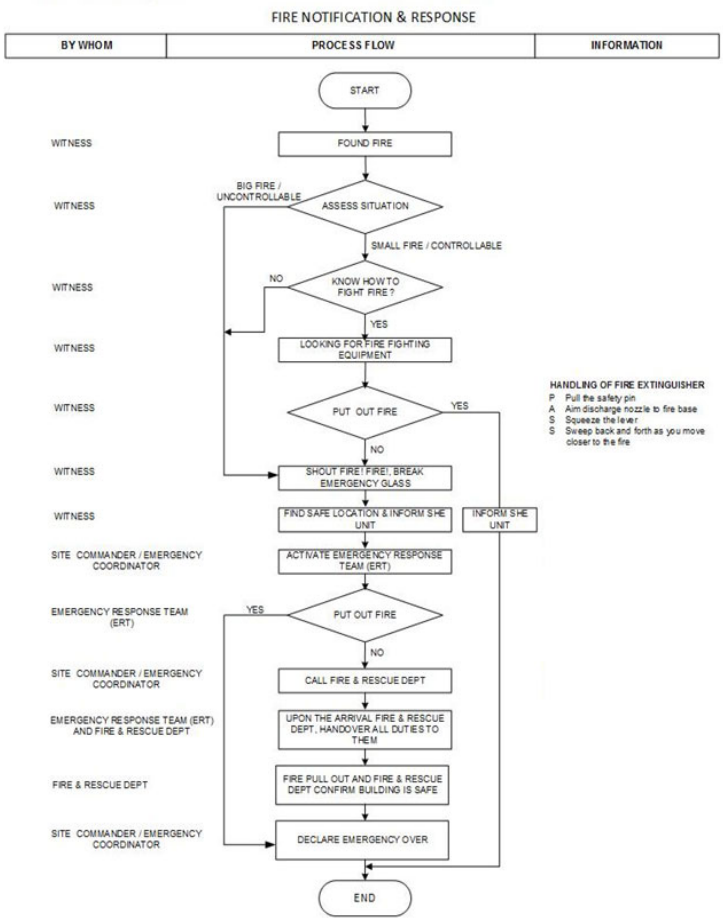

Figure 1. Process Flow of Fire Notification And Response

No	Descriptions	Status	No	Descriptions	Status
A. PRODUCT ENGINEERING DEPARTMENT (3)			J. VISITOR /VENDOR		
1	Employee 1			Location	
2	Employee 2		1	Meeting room 1	
3	Employee 3		2	Meeting room 2	
PROCUREMENT DEPARTMENT (5)			3	Meeting room 3	
4.	Employee 4		4	Meeting room 4	
5.	Employee 5				
	...			...	

Figure 2. Sample of Checklist Form Notification and Response

Figure 3 shows the system architecture of IoT-RePCO. The first phase of this systems known as monitored zone. In this phase, the image will be detected and captured. To monitor it, some limit lines are required, to determine the entrance or exit from objects.

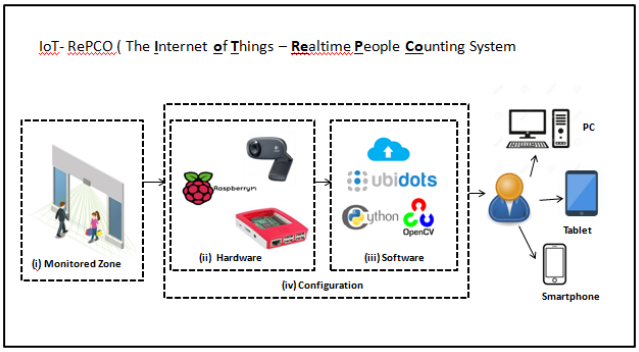

Figure 3. Systems Architecture IoT-RePCO

These limit lines consist of virtual lines plotted over images by OpenCV. There are two limit lines; *Entrance line* (Blue):reference line that defines the limit for an object to enter in monitored zone and *Exit line* (Red) :reference line that defines the limit for an object to exit of monitored zone. Observe the monitored zone representation is shown in Figure 4. The second phase are the configurations which consists of hardware and software setup integration as shown in Figure 5. The USB camera was inserted into the USB slot provided on the PI, an Ethernet cable is connected to the Ethernet ports of both PI and the laptop to access PI remotely. The micro USB 5V 2.5A was used to power Raspberry pi. Details process flow of the system is visualise in Figure 6.

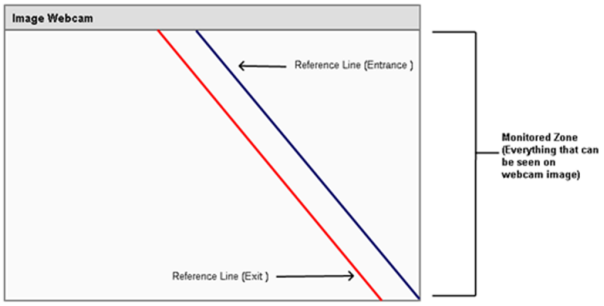

Figure 4. Monitored zone, entrance and exit lines

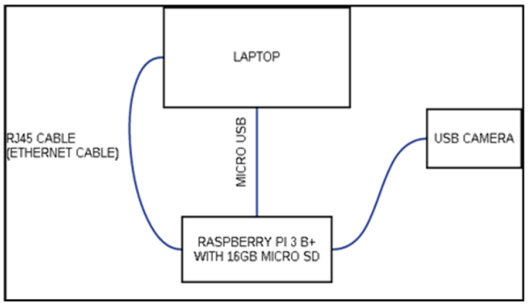

Figure 5. Configuration of Hardware

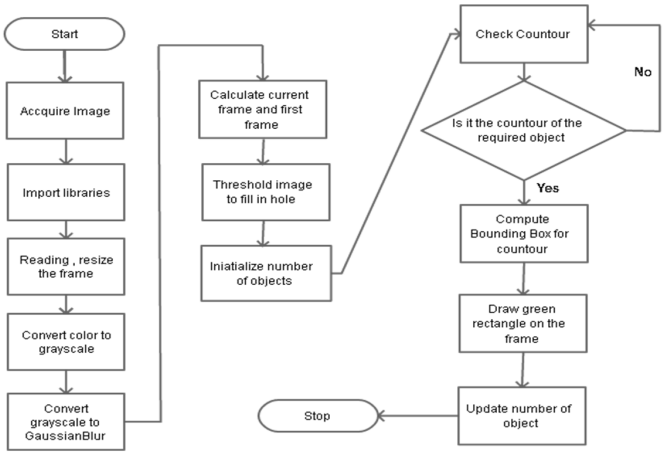

Figure 6. Flow Chart of the IOT - RePCO system

Dashboard visualisation on the last phase were meant for emergency handler and safety manager as well as for the administrator. It shows in graph forms the counted people and the total number of users. Figure 7 and 8 shows the dashboard respectively. The real time image acquisition from the former phase is automatically counted and generate a report upon request from the system users.

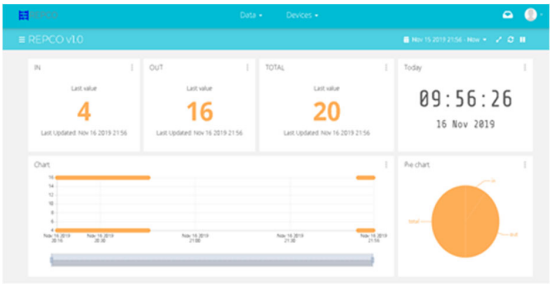

Figure 7. Dashboard for Emergency Handler and Safety Manager

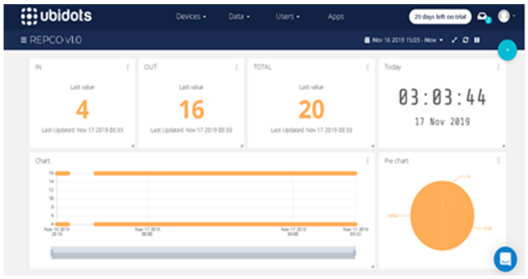

Figure 8. Dashboard for Administrator

4. Conclusions

The People Counting system is developed to assist emergency responder as well as the safety manager to count the exact number of employees and visitors during the evacuation process at large corporation. This system also aims to fulfil the demand of counting, detecting as well as managing and storing records in real time. The system was designed to run in Python using Raspberry Pi in OpenCV framework. It can be accessed via different channel such as personal computer, tablet and smart phones. IOT- RepCO system is far more accurate as compared to optical sensors when detecting and identifying the differences between people or things. Other than that data generate is not tied up to propriety system resulting unlimited option for data extraction and optimization. Using the cloud to enable RepCO enhanced overall functionality. With increased capabilities in the form of visualizations, reporting, alerting, and cross-referencing outside data sources (In, Out, And Total counted visitor). For future works, the improvement of the width measures of the blob person can be made for detecting an exceeding threshold, to classify it as several people. However, in some cases, single people appeared to be wider in certain locations and orientations which is mostly because of the effect of camera angles. Another recommendation is by assigning trail to the people who are going out or going in with different colour. In this project, red colour trail is used to track people who is going out while blue colour is used to track people who is going in. The idea is to able to trace and differentiate the person's identities in case if one crosses another. it is advisable to have local data storage as further enhancement as this data will be stored in temporary folder before data is parsed to the cloud storage. Reasoning behind this suggestion is to prevent from data loss in the event of internet breaks down. Therefore, the data will be stored temporary until the internet is secured.

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