Automatic Queue Monitoring in Store Using A Low-Cost IoT Sensing Platform

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***Abstract*—In this paper, the problem of queue in convenient stores is considered. We propose a low cost automatic queue length monitoring system by using an Internet-of-Things (IoT) platform. This system can detect the length of queue and the number of people that enqueue and leave the queue. If the length of queue is critical, the system will alert to staff via LINE Notify. Experimental results indicate that our system can perform people counting and notify in real-time. And the average accuracy rate is 95% for people counting and 86% for notification, respectively.**

I. Introduction

Customer satisfaction is the core of a good service. In convenient stores, customers need a good and quick service, especially for payment. Many customers leave without buying anything in Thailand because the payment queue is too long and not well managed. Thus automatic queue monitoring system is important to solve an this problem.

The queue monitoring research mostly was applied in intelligence traffic signal [1]. The system will control the time by using vehicle length during red cycle [2]. The camera was installed at crossroad and the system detected vehicle in real-time. After that the image was processed though image processing techniques. In [3], Haar feature based AdaBoost cascade was used to detect vehicle queues in rush hours. The system achieved the good accuracy rate of 91.54%. Progressive block was applied to queue detection at traffic junction in [4]. This method could archive the highest accuracy rate that was 100%.

Different from the queue of vehicles, the queue of people is more complicated. There are some commercial products to deal with the people, such as QTracIQ [5], AllGoService [6], True view Queue [7], Video Turnstile [8] and 3VR [9]. Most of these products use the overhead camera and conduct image processing on PC or high performance computer. The systems can count the number of people as they enter and exit the queue and estimate the waiting time. Some systems can alert when queue is too long. True View Queue and QtracIQ alert by sending video, email or message to users. AllGoService and Video Turnstile do not provide the alert service. QtracIQ employed another type of sensor instead of camera. A sensor can cover one meter radius but it is inflexible and expensive.

This is a collaboration project for joint internship program between Panyapiwat Institute of Management, Thailand, Future Standard Company and Yamasaki Lab of The University of Tokyo, Japan

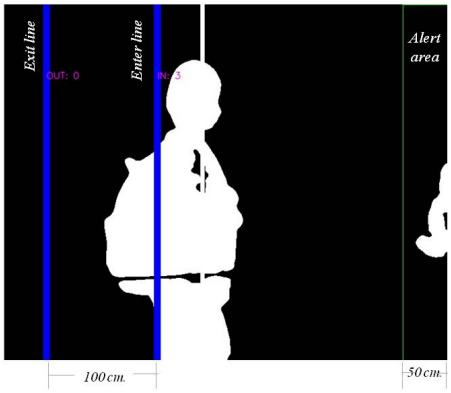

Fig. 1. Layout of detecting and critical areas in a camera frame

In this paper, a queue monitoring system is reported on a very low-cost device in real-time processing. It can recognize the length of queue and alert via LINE Notify when the queue is too long. It can also count the number of people who enter and exit the queue. The system is operated on a IoT platform by using webcam and Raspberry Pi 3. The device is low-cost and easy to install.

II. Proposed Method

Our proposed technique is presented in Algorithm 1. The critical zone will be predefined for alert. Fig. 1 shows the location of detecting lines and critical zone. Because the camera is installed at the side view of queue, people should not overlap to avoid the incorrect counting.

The information from the people counting history can help the owners analyzing their customers and determining the opportunity cost.

For making our alert system easy to use and low-cost. LINE Notify is the best solution. We set the LINE notify alert, when the queue is in critical zone more than 10 second. It will be notified to staffs every 30 seconds, while the queue is still detected in the critical zone. For the implementation cost, our

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Fig. 2. System Devices

Data: Sequence of images $\{I_t\}$
Result: Number of people who enter and exit the queue and alert via LINE Notify when the queue reaches the critical zone
initialization;
Set critical zone;
Set f to the number of frames when critical zone detected Set N_{in} and N_{out} to zero;
while *not end of* $\{I_t\}$ **do**
  Read images I_t ;
  Apply background subtraction, Gaussian blur and morphological opening to I_t, respectively ;
  Convert I_t to a binary image B_t;
  Set C_{in} and C_{out} to the number of white pixels of B_t in their detected areas;
  if *frame equal 1* **then**
    Set I_t as a background ;
  else
    Calculate absolute different within all detection regions;
    Convert image to gray scale;
    Set P to the number white pixels in critical zone ;
    if P *is more than the threshold for* f *frames* **then**
      Alert message via LINE Notify;
    end
  end
end

Algorithm 1: Queue monitoring algorithm

proposed is low-cost compared to the commercial solutions in [8], [10], [6]. Because all of these products need the Personal Computer to operate the algorithm. Normal PC cost is around $300 while our Raspberry Pi 3 costs only $35.

III. Experimental Result

Our system is operated on Raspberry Pi 3 model B with Raspbian version 8.0 (Jessie) and USB webcam (angle of view 60 degrees) as shown in Fig. 2. It is implemented with Python version 2.7.9 and OpenCV library version 3.1.0. The processing frame rate is 8.45 frames per second with 320×240 video resolution. The system can be connected to the Internet using WiFi or using a SIM card to send notifications. The total cost of the system is less than US$200, which is very low-cost as compared to the other off-the-shelf systems.

We test our system performance with 42 persons. It can achieve the average accuracy rate is 95% for people counting and 86% for alert. Fig. 3 shows the example of false alarms, this error occurred because a sudden lighting changes at the tail of queue and then the background subtraction cannot adopt to it immediately. In our experiment, there are only 2 false alarms.

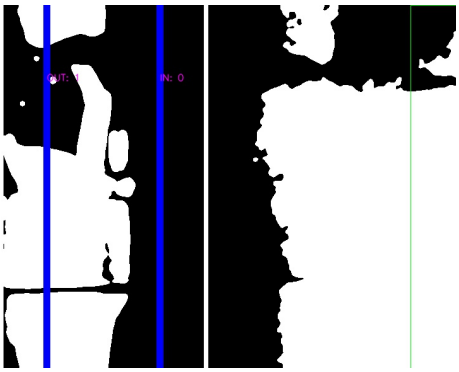

Fig. 3. Example of false alarm

IV. Conclusion

This paper proposed automatic queue monitoring by using a low-cost IoT sensing platform. We operated the system on Raspberry Pi 3 and single USB camera. Our system can count the number of people in a queue, detect queue length and alert via LINE Notify in real-time. Experimental results demonstrated that we could achieve 95% accuracy in people counting and 86% accuracy in sending alert.

References

[1] Y. Yao, K. Wang, and G. Xiong, "Embedded technology and algorithm for video-based vehicle queue length detection," in *Proceedings of 2013 IEEE International Conference on Service Operations and Logistics, and Informatics*. IEEE, jul 2013, pp. 45–50. [Online]. Available: http://ieeexplore.ieee.org/document/6611379/

[2] Y. Cai, W. Zhang, and H. Wang, "Measurement of Vehicle Queue Length Based on Video Processing in Intelligent Traffic Signal Control System," in *2010 International Conference on Measuring Technology and Mechatronics Automation*. IEEE, mar 2010, pp. 615–618. [Online]. Available: http://ieeexplore.ieee.org/document/5459488/

[3] D. Yang, L. Xin, Y. Chen, Z. Li, and C. Wang, "A robust vehicle queuing and dissipation detection method based on two cameras," in *2011 14th International IEEE Conference on Intelligent Transportation Systems (ITSC)*. IEEE, oct 2011, pp. 301–307. [Online]. Available: http://ieeexplore.ieee.org/document/6082828/

[4] R. K. Satzoda, S. Suchitra, T. Srikanthan, and J. Y. Chia, "Vision-based vehicle queue detection at traffic junctions," in *2012 7th IEEE Conference on Industrial Electronics and Applications (ICIEA)*. IEEE, jul 2012, pp. 90–95. [Online]. Available: http://ieeexplore.ieee.org/document/6360703/

[5] QtracIQ, "QtracIQ." [Online]. Available: http://qtrac.lavi.com/people-counting/

[6] A. V. Analytics, "AllGoVision Video Analytics." [Online]. Available: http://allgovision.com/

[7] T. Queue, "TrueView Queue." [Online]. Available: http://www.cognimatics.com/Products/TrueView-Queue

[8] V. Turnstile, "Video Turnstile." [Online]. Available: http://videoturnstile.com/queuing-system.html

[9] 3VR, "Queue Management Analysis — 3VR." [Online]. Available: http://3vr.com/products/videoanalytics/queueline

[10] R. Sensing, "Retail Sensing." [Online]. Available: http://www.retailsensing.com/queue-management.html