# Face Detection and Tracking based People Counting System

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## 1. Introduction

Intelligent video analysis systems are increasingly employed to provide statistics of customers. People counting is critical among several components of commercial purpose intelligent video analysis. There are many challenges that make people counting a difficult problem such as non-human objects, illumination changes, occlusions, scale and shape changes, fast motions and real-time processing. There have been several methods proposed to solve these difficulties. Background subtraction based methods have weaknesses when occlusions or illumination changes occurs. People identification based people counting method is accurate but requires heavy identification algorithms. Multiple-object detection and tracking based people counting method can be a promising solution to the counting problem because of its inherent robustness to non-human false positives, occlusions, illumination changes and real-time processing capability.

In this paper, we propose a novel people counting system based on face detection and tracking. The proposed system is superior to the widespread background subtraction based methods which are vulnerable to the non-human false positives and also is superior to the people identification based methods in terms of processing speed.

## 2. Proposed Algorithm

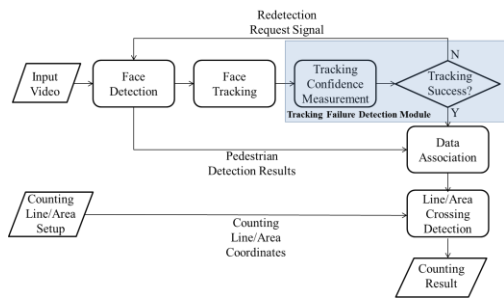


Figure 1. Overall block-diagram of the proposed people counting system.

The proposed people counting system consists of face detection module, face tracking module, tracking failure detection module, data association module and counting module. Overall block-diagram of the proposed algorithm is depicted in Figure 1.

Local binary pattern (LBP) features with AdaBoost classifier [2] is employed to detect every face in the input frame. Open Multi-Processing (OpenMP) is employed at the implementation to speed up the face detection. In order to increase the processing speed further, face detection is performed for only every third input frame. $64 \times 64$ is a minimum size of the face detection. Detected faces are fed into face tracking module and data association module.

The tracking framework is based on Choi and Yoo's multi-person tracking algorithm [1]. Hue saturation value (HSV) histogram is employed as an observation model and Gaussian perturbation is employed as a motion model in a particle filter based tracking framework.

In order to detect the tracking failure, we define a criterion for tracking lost or success decision as follows.

$$Status(k) = \begin{cases} 0, & \text{if } \rho[I_{\mathbf{s}_t^k}, I_t^k] < \rho_{th}, \\ 0, & \text{if } \rho[I_{\mathbf{s}_t^k}, I_t^k] - \rho[I_{\mathbf{s}_{t-1}^k}, I_{t-1}^k] < \Delta_{th}, \\ 1, & \text{otherwise.} \end{cases} \quad (1)$$

If the tracking failure detection module detects tracking lost by (1), lost signal 0 is transmitted to the face detection module to request a redetection of the lost face. Otherwise, tracker estimates the state of the current tracking face by particle filtering as usual.

To assign the face detection result to the trackers, data association method is required. Greedy data association is employed to solve the assignment problem with the matching score defined as follows.

$$M(\mathbf{s}_{\text{tr}}, \mathbf{s}_{\text{det}}) = \alpha p_N(|\mathbf{s}_{\text{tr}} - \mathbf{s}_{\text{det}}|) + \beta \rho[I_{\text{tr}}, I_{\text{det}}]. \quad (2)$$

The face detection result with the maximum matching score is associated with the tracker. The associated face detection result and the tracker are excluded from the matching pool. The same procedure is processed until there is no valid pair in the matching pool.

Both line based counting and area based counting is possible in the proposed counting system. If line based counting system is used, the proposed system counts the people crossing the pre-configured line with the pre-configured counting direction (e.g. top to bottom, left to right, etc.). Otherwise, the proposed system counts every people being tracked in the scene. The same persons re-entering the scene could yield some redundant counting error. Redundant counting errors can be reduced if a person identification module is incorporated in the system.

## 3. Experimental Results

The proposed people counting system is tested at a PC with Intel® i7-3770 quad-core 3.4GHz CPU. The number of particles per tracker is fixed to 100. The number of samples to construct a color histogram is set to 250.

The sample frame of the proposed people counting system is depicted in Figure 2. Area based counting is employed in this test. A woman outside the door is not detected, therefore is not counted yet. The woman was not detected since the face size was not large enough to detect (smaller than $64 \times 64$ pixels). However, after some frames, the woman walks into the room and the face size becomes large enough. Consequently the system detects her face and increase the count successfully.

People counting accuracy is described in Table 1. The average counting accuracy is 95.2% and the lowest counting accuracy is 88.2% for ETRI DB2. The reason for inferior counting accuracy for ETRI DB2 is several face detection failure occurs in ETRI DB2. The processing speed of the proposed system shows over 20fps which is sufficient for real-time applications.


Figure 2. The proposed people counting system based on face detection and tracking.

[Table 1] The experimental result of people counting.

| Test Data | Result/Ground Truth | Counting Accuracy |
|---|---|---|
| ETRI DB1 | 31/32 | 96.8% |
| ETRI DB2 | 30/34 | 88.2% |
| ETRI DB3 | 60/61 | 98.3% |
| Total | 121/127 | 95.2% |

## 4. Conclusion

In this work, we proposed a real-time people counting system based on face detection and tracking. The proposed system shows 95.2% counting accuracy and over 20fps processing speed which is suitable for real-time applications. The proposed people counting system is expected to be applied to customer statistics analysis systems.

## 5. Acknowledgement

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## 6. References

[1] J.W. Choi, and J.H. Yoo, “Real-time multi-person tracking in fixed surveillance camera environment”, in *IEEE International Conference on Consumer Electronics*, 2013, pp.125-126.

[2] T. Ahonen, A. Hadid, and M. Pierikainen, “Face recognition with local binary pattern,” in *European Conference on Computer Vision*, 2004, pp. 469-581.