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People Counting at Campuses

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Abstract

People counting systems aim at automatically estimating the number of people indoor and outdoor places. They are widely used in retail environment; determining conversion ratio, advertising and promotional evaluations. And they can be used for transportation management system and video surveillance. This paper presents a model of estimating the number of people in several scenarios at campuses based on face detection. Several considerations for counting people at campuses are illustrated in this paper, and experimental results of the developed method are explained and shown preliminary results. Moreover, it is investigated the possible importance of people counting in the scenarios where potential learners are watching a bulletin board and are captured via a single camera.

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Keywords: People counting; face detection; bulletin board; computer vision; education

1. Introduction

People counting systems aim at automatically estimating the number of people indoor and outdoor places (Zhao, Delleandrea & Chen, 2009). There are many advantages of using people counting systems. For instance, counting the number of viewers in a shopping mall may provide valuable information for optimizing trading hours, as well as evaluating the attractiveness of some shopping areas or shopping items (Chen & Lin, 2009). They are widely used in retail environment; determining conversion ratio, advertising and promotional evaluations. And they can be used for transportation management system and video surveillance. Moreover, Barbara Winkler-Chimbor, Director of Global Education Market Development, Genetec said "post-secondary education institutions are looking to add

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people counting at events to assess capacity at stadiums to plan evacuation procedures during emergency situations such as fires and weather related emergencies" (Wang, 2012). In brief, people counting systems are very important in many real-world applications.

Kamel et al. (2004) classify people counting systems into two categories; obstructive and non-obstructive (as cited in Prabakaran, Arthanariee, & Sivakumar,2011). Turnstiles and mat-type foot switches are some of the examples of obstructive people counting systems (Prabakaran et al., 2011). Turnstiles have the drawback of high cost, low flexibility and can obstruct the passage way (Liu et al., 2005). If there is high-density people flow-traffic, it can cause time consuming (Velipasalar,Tian, & Hampapur, 2006). Moreover, they have the limitation of possible undercounting. Non-obstructive systems such as infrared beams or thermal (heat) sensors do not block the doorways; however they suffer from the same undercounting problem (Velipasalar et al., 2006).

Computer vision technology-based system, one of the non-obstructive people counting systems, is an alternative to other systems. Comparing to other people counting technologies, computer vision technology-based systems have the advantage of higher accuracy, inexpensiveness and non-intrusiveness (Wang, Lee, Chung, & Chen, 2005).

In this paper, a people counting system based on face detection was developed in order to count people at a university campus from a single camera and several considerations for counting people at the campus are illustrated. 5-minute-videos were captured by a camera at several places; corridor, library and computer laboratory. Among these scenarios, we focus on counting the number of people, as potential learners, watching a bulletin board at the corridor. The aim of this research is to show people counting systems can be also used at the campuses not only for surveillance or emergencies but also for a possible helpful tool supporting the education.

This paper is organized as follows: Section 2 describes the system architecture of the proposed people counting system. In Section 3 presents the experimental results and conclusion.

2. Method

Proposed people counting system based on face detection automatically detecting a human face from the video was built by using Microsoft Visual Studio 2010 edition and OpenCV 2.4. OpenCV offers a very efficient tool for face detection – Haar classifier and a boosted rejection cascade, known also as Viola-Jones detector (Kozłowski & Królak, 2009). Viola-Jones detector was used to detect frontal human faces in video sequencies for face detection. In proposed system, we used the motion history of the detected faces to identify the same face in different frames. If the positions of the same detected face could be quite close among different frames, we can say they are quite likely to be in the same connected component in the motion history (Tu, 2006).

The pseudo code of the system is;

```
for each detected face
        do smaller size rectangle at the same position
for each connected component
begin
        if face detected first time then give new id
        else// previously detected
        begin
          give the id of previously detected face to currently detected face
          if id occurrence number==threshold number  then Count Face
        end
end
```

A rectangle was drawn with smaller size at the same position for each detected face rectangle within a certain length of history. Then, if the face is detected first time in each connected component, then a new id is given. If there is a previously detected face, the id of previously detected face is given to the currently detected face. To protect from noises caused by being counted, we defined a threshold number, if detected faces' occurrence number in same connected component is more than it, faces are counted (Tu, 2006).

To test the proposed system, 5-minute-videos were captured by a Kodak Easyshare M763 digital camera (7.2 mega pixels) at several places at Başkent University campus; corridor, library and computer laboratory. MOV to AVI video converter (Pazera Free MOV to AVI Converter) was used to convert MOV camera-output videos into H.264/MPEG-4 AVC. Four different resolution sizes of videos were used; 240x180, 320x240, 352x288 and CIF (352 × 288). The frame rate of the videos was approximately 15 fps. The system was tested on notebook (Intel® Core™2 Duo Processor 2.40GHz, 3GB memory).

2.1. Implementation Location: Corridor: Bulletin Board

People counting system was implemented above the bulletin board at the corridor to count how many people have checked it. Bulletin boards are visual displays that provide information using pictures only, words only, or picture and words for people of all ages (Raines & Williamson, 1995). Bulletin boards serve a variety of purposes; displaying student work, providing students practical information about classroom rules or announcements, serving as an activity board for students, or decorating the classroom. Bulletin boards are a good place to post reminders or frequently used concepts such as rules, steps for beginning a lesson, or a schedule of activities ("Organization and Management of the Classroom," n.d.). In this scenario, the bulletin board implemented at the corridor is showing announcements.

2.2. Other Implementation Locations: Library and Computer Laboratory Entrance

Proposed people counting system was also implemented at other possible places can be used at campus; at the library and computer laboratory entrance to count how many people enter through the door.

3. Findings and Interpretations

To evaluate the overall performance of the proposed people counting system, 5-minute-videos were captured at several places; corridor, library and computer laboratory at the university campus.

The accuracy and results of the proposed people counting technology based on face detection is shown in Table 1. *Real number* represents the number of people who's watching the bulletin board at the corridor or going inside to library or computer laboratory according to scenarios. *Counting Number* shows the number of people the system counted in total and *True Counting Number* represents number of people our system counted correctly. *False Counting* and *Not Counting Number* represents the errors of the system; *False Counting Number* shows counting the face of a person 2 times by result of the person's movement, counting the upper side of the T-shirt as a face or a person who's checking the camera while going out of the library and *Not Counting Number* shows the number of people watching the bulletin board less time with distorted head (not frontal face).

To assess accuracy of the proposed people counting system is presented by using the formula;

$$\text{Accuracy}(\%) = \frac{\text{True Counting Number}}{\text{Real Number}} \text{ x } \%100 \quad (1)$$

Table 1. The accuracy/results of people counting.

Sequences	Resolution (pixels)	Real Number	Counting Number	True Counting Number	False Counting Number	Not Counting Number	Accuracy
Corridor: Bulletin Board (273 sec)	240x180	14	7	7	0	7	50%
	320x240	14	11	10	1	4	71,42%
	352x288	14	15	12	3	2	85,71%
	352x288 (CIF)	14	14	12	2	2	85,71%
Library (311 sec)	240x180	10	8	7	1	3	70%
	320x240	10	15	9	6	1	90%
	352x288	10	13	9	3	1	90%
	352x288(CIF)	10	15	9	4	1	90%
Computer Laboratory Entrance (309 sec)	240x180	5	5	5	0	0	100%
	320x240	5	7	5	2	0	100%
	352x288	5	5	5	0	0	100%
	352x288(CIF)	5	6	5	1	0	100%

3.1. Implementation Location: Corridor: Bulletin Board

The best results were obtained by 352x288 pixels (CIF) video. The accuracy rate was 85,71%.The errors in Corridor: Bulletin Board-video were caused by watching the bulletin board less time with distorted head (not frontal face) and counting people 2 times by result of the person's movement.

3.2. Other Implementation Locations: Library and Computer Laboratory Entrance

The people counting system performed best in 352x288 pixels video at library entrance. The accuracy rate was 90%. The errors in library-video were caused by false detection of the system; counting the upper side of the T-shirt as a face ,counting the face of a person 2 times by result of the person's movement, distorted head (not frontal face) and a person who's checking the camera while going out of the library.

At computer laboratory entrance, 352x288 pixels and 240x180 pixels video gave the best results. No error occurred in the scenario. The accuracy rate was 100%.

4. Conclusion and Discussion

This paper presents a people counting system based on human face detection method. The counter can count the people, even more than one person at a time, checking a bulletin board or passing through a door.

The experimental results show that the proposed method can achieve a high accuracy. The average accuracy was 83,74%. The errors occurred mostly by counting people 2 times by result of the person's movement and distorted head (not frontal face). If the camera captures the frontal faces, the accuracy can be increased. And false detection occurred caused by a person who's checking the camera while going out of the library. The experimental results show the accuracy of the system depends on the quality of video and scenario. The best results were obtained by 352x288 pixels videos.

Implementation locations are deliberately chosen related to education areas to show people counting systems can be used as a helpful tool for educational purposes. We focus on counting the number of people, as potential learners, watching a bulletin board at the corridor. With the help of estimating the people checking bulletin board, the effectiveness of the bulletin board can be evaluated in many aspects. If the counted people are less, the bulletin board may not be visually appealing to possible learners and not attract attention and the educators should consider the optimal location for bulletin boards (Thomas, 2007). In bulletin board at the corridor scenario, the bulletin board was showing announcements. It may be planned for other educational purposes such as presenting information about a specific topic, showing students display**,** and etc. By the proposed system, the number of the people who are actually aware of the bulletin boards in the classrooms or corridors can be counted. Moreover, the proposed people counting system was implemented at other possible places, where it could be used, at campus; library and computer laboratory. For instance, we can learn the capacity of study place at library is enough or not, or where potential

learners are checking the books in the specific area the most. By counting the people at computer laboratory we can have an idea about its capacity is enough or not. Other implementation places can be offered for other purposes; at the buses and bus stops for the effective university transportation system, at the conference hall, dining hall, sports center, concert area, and etc.

At the following studies, more cases will be considered and the proposed algorithm will be modified by adding skin color detection and motion detection to get higher accuracy.

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