OCCUPANCY IN A CLASSROOM

ESTIMATING THE NUMBER OF PEOPLE IN A ROOM

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Abstract: *Energy savings is one of the core issues scientists are concerned with. In this article, one aspect of energy saving is discussed. We have considered a classroom/office scenario where we consume significant amounts of energy for lighting, ventilation and heating/cooling. To prevent unnecessary use of energy when nobody is in the space or to adjust the systems operation to the number of occupants, we have proposed a method that will allow us to know the number of people available in a classroom in a real-time scenario. Spatial occupancy and Face detection method have been discussed here to count the number of people. Experiments using image processing are performed. Due to the robust output of face detection method using Viola-Jones algorithm we have found this more effective.*

Keywords: *save energy; number of people; face detection; Viola-Jones method.*

1. Introduction

It is important to know how many people are present in a room (classroom in education buildings or offices spaces) at a certain time in order to optimize the use of electricity. Human detection in images is a challenging task owing to their variable appearance and variation in poses that they can adopt [Wang, 2007]. First, to discriminate cleanly, even in cluttered backgrounds under difficult illumination we need a robust feature set, such as facial properties, human body shapes etc. Detecting a specific object class in a set of images or video sequence is known as object detection. It is an important, yet challenging vision task. Face detection techniques have been researched for years and are regarded as the most complex and challenging problems in the field of computer vision. The face detection method focuses on the frontal faces with sufficient illumination conditions.

We have developed a strategy capable of detecting faces in a color image of the classroom with very high accuracy rate. The problem that we are dealing with is discussed in section II. Section III describes the two different ways that we have tried to achieve the goal - determine Space Occupancy based on Face Detection - in which the face detection using Viola-Jones algorithm [Alionte, 2015] is mainly highlighted. The limitations of the face detection method are also briefly mentioned in section III. A modified perspective of the face detection method has been shown in section IV. Finally, conclusions are presented.

2. Problem

Generally, some energy is wasted in spaces occupied by multiple users. For an instance, during an ongoing class even if there are a smaller number of students than the average and more than half of the room is vacant, we keep the light, ventilation and heating and cooling systems turned on for the

whole room and the maximum number of possible users. Also, when there is nobody in the class, energy is being continuously used, wasting of energy and money.

To prevent these kinds of misuse of electricity and money, we have developed a system to monitor the classroom and detect the number of people in the room at a certain time. By estimating the correct number of people in the room we will be able to control the energy consumption by adjusting the system to the occupation of the space. Therefore, in this article we have presented a method to count the number of people in a classroom or in similar cases.

3. Approaches

There are several methods to detect the persons in an image. But when it comes to a classroom scenario it becomes very complicated to find the people. In this section, the different approaches to find the specific objects and count the number of relevant objects have been discussed.

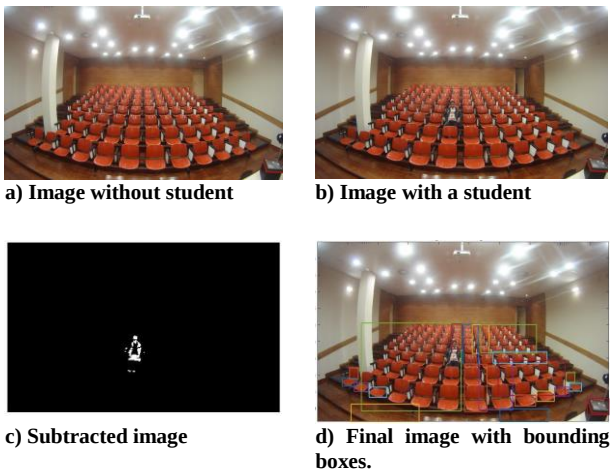
Before going for the detection, we have to set certain conditions for a better result. Brightness is one of the key factors for these kinds of detections. If the image has been taken during the day, the illumination condition can literally affect the image by increasing the brightness but if it is taken during night then it is crucial to have sufficient artificial light to get a better output. Another factor to notice is the color temperature. We need to maintain proper color temperature to maintain the same image condition for multiple shots. The size of the room also becomes very important in order to detect the faces and till ta certain distance (depends on the camera), the image can produce good results. If the room is relatively bigger then this certain distance, it becomes difficult to count the number of people through both special occupancy and face detection. Also, to get an accurate result, the picture quality must have to be good in quality.

The system was implemented using image processing in MATLAB R2016a with adequate toolboxes. Our approach mainly relies on object detection, first with a need for background subtraction and second with face detection. To achieve the goal, initially we did image comparison to find the space occupancy but later as we did not get an efficient result, we opt for face detection method. Both the methods are discussed below,

3.1 Space Occupancy

Space Occupancy method uses the space occupied by each people to estimate the number of people by comparing two images since each person occupies specific space in the room.

For this, we first take two images: one is when there was no student in the class and another is with the students in the class. We resize the image and convert both the images into gray scale. Then we subtracted the images to find the difference and space occupied by the student. Later the color space has been changed and the holes are filled. The feature extraction procedure is done to find the specific region of interest. Then we continued with blob measurements and draw the boundary boxes. Counting the boundary boxes, we can count the number of people. But in this case the blobs show unexpected results (Figure1) which causes the failure of this method as per our procedure.



a) Image without student **b) Image with a student**

c) Subtracted image **d) Final image with bounding boxes.**

Figure 1 *Counting with Space Occupancy method*.

3.2 Face Detection

A face detection method has to say whether an image of arbitrary size contains a human face and its placement. In the framework of binary classification this problem has been considered, where the classifier is used to minimize the misclassification risk [Ahuja, 2002]. Actual prior probability to have face in a given image is not possible to describe through objective distribution. To achieve the acceptable performance, the algorithm must minimize the false positive and false negative rates.

Viola-Jones face detector is one of the most extensively used learning based methods. Because of its rapid computation of Haar-like features, classifier learning with AdaBoost and the attentional cascade structure, it can run in real-time [Wang, 2014]. A complete description of Viola-Jones face detection method is presented in Fig.2. For creating the system object detector for the image, we used vision Cascade Object Detector. There are two main steps for face detection. One is face location for finding the face candidates and another is facial feature detection for verifying detected face candidates [Merialdo, 2012]. To be successful, a face detection algorithm must possess two key features, accuracy and speed. We have introduced the tic-toc feature to count the time taken for each processing which helped us to improve the speed of the processing. Using the i7, 2 GB RAM we have achieved the minimum processing time around 0.98 sec were obtained.

The block diagram represents the steps followed to detect the faces from the color image. At first, we read the input image and convert it to a black and white image. As we took the picture in the evening, there was lack of sufficient illumination; as a consequence, we set the parameter to control the brightness for a better result. Next, we define the face detector object and extract features to find the boundaries of the object and draw the bounding boxes. Then, we count the number of bounding boxes which represents the number of people.

3.3 Limitations of the method

The result of face detection highlights the limitations of this method are given below,

- One of the demerits of Viola-Jones method is that it hardly detects the change of tens of degrees in angle and that is why it could not detect the student on the front row of Fig.3.
- The two students on the extreme back are not detected because of the unclarity and small size which also lower the efficiency of this method.

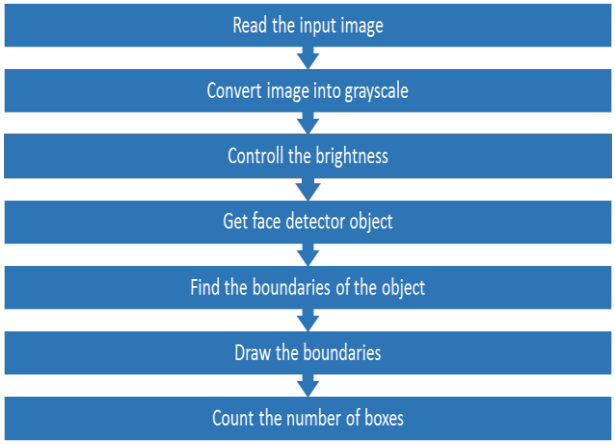


Figure 2: *Sequence of Face Detection Algorithm*

4. Improvements

Improvements have been achieved, especially in the case of limited angle problem. For instance, (e.g. outside the classroom) a small rotation of the picture can make clear improvements as shown in Fig.3. We have rotated the Normal Image. This improvement shows that the model can be largely used with further improvement. Here noticeable that the two persons on the back-left side are also detected which makes the Viola-Jones method more effective than others.

It allows us to detect a person even just with the face (Table 1). This result suggests that the counting of the number of people inside the classroom could be improved with higher efficiency using multiple shot of images along with image rotation feature which in this case results the maximum efficiency.

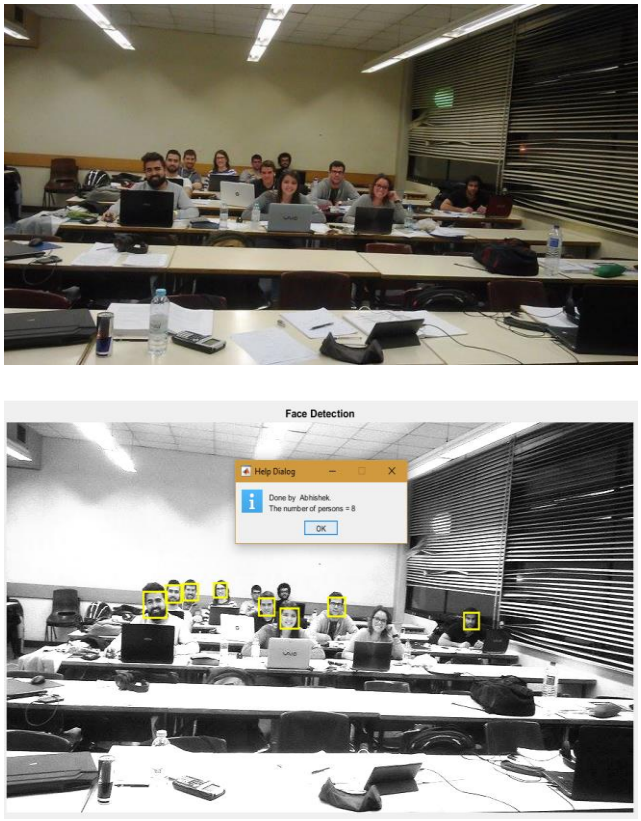


Figure 3 *Counting people using face detection.*

Table 1: Efficiency of different approaches

Approaches	Real Faces	Detected Faces	Efficiency (%)
Space Occupancy	1	0	0
Face Detection (Classroom)	11	8	72
Face Detection (Outside the classroom)	14	14	100

5. Conclusions

Detecting people in a classroom such as in Fig.2 is a real challenge and still an open problem. Examples presented show its feasibility and thus the interest of such an approach. Tests such as verifying the algorithm in more complicated scenario of a classroom should be performed, in order to evaluate robustness of the approach under research. It is very encouraging to see the achieved efficiencies using Viola-Jones algorithm. We further examined the errors of our test set with slight improvement to understand the performance of the algorithm. We found that with the improvement in angle it becomes more effective which proves the success of this model. By detecting the people in a set of images with a certain angle of rotation in each image, we could count the exact number of people available in the classroom. Upon completion, many other task can be pursued complimentary, as, for instance, face recognition or correlate people with specific position.

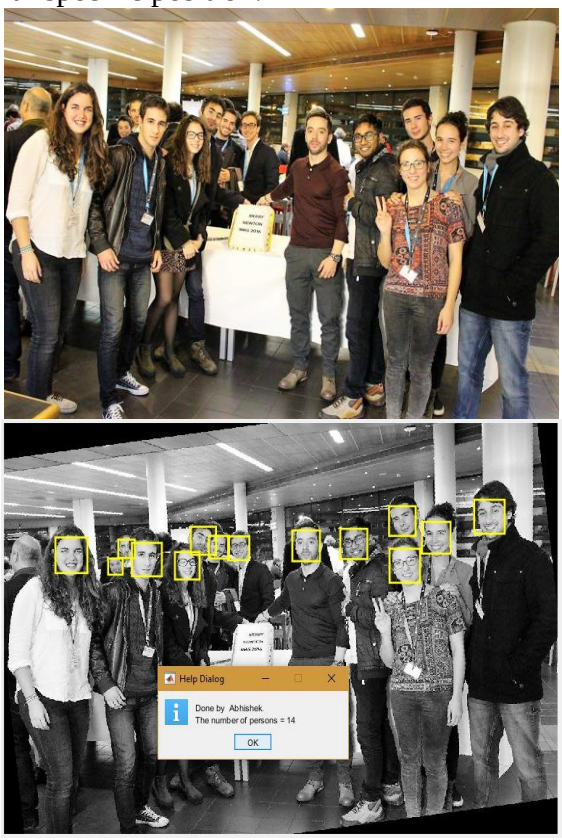


Figure 4 *Face detection with 100% efficiency.*

Acknowledgements

Authors thankfully acknowledge the support provided by the students who kindly allow the pictures to be made.

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