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INDOOR CROWD DETECTION USING RGB CAMERA AND IoT

S.Kalaivanan [*1] & Amrutham Suresh Kumar[2]

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ABSTRACT

In the age of automation the ability to detect the crowd in an indoor environment is impossible without being physically present in the area. IoT (Internet of Things) has moved the field forward by automating anything anywhere. Monitoring the crowd is a critical task in a civilian place. Ubiquitous vision based techniques mostly involve in counting techniques. Counting techniques are prone to error in a dense crowded environment. This paper proposes a technique to detect the density of the crowd with the help of heat map representation. The indoor environment which is to be monitored has to be fitted with RGB cameras. Initially the area is captured using the camera without any crowd/people and stored in the database. Once the model is deployed the camera captures the image of the area every second and sends it to the database. A comparison of the already stored map and the newly captured map are performed using the SURF algorithm. The difference recorded is then sent to the database and retrieved by the application and displayed in the form of a heat map. The heat map is regenerated every one second and the density of the crowd is displayed in RGB colors on a heat map. The results show that the heat map gives accurate density of the crowd.

INTRODUCTION

Shopping malls, exhibitions and Stores are where crowds gather in a huge amount irrespective of how far it is. Taking a shopping mall for instance, is present all over the world almost in every city. It is proved to be the most visited place by any individual. When there is huge crowd at a mall/shop the persons aim to shop reduces, they automatically prefer a less crowded place. In the real time scenario one cannot visit the place and then go back as it is crowded or in a mall one floor might be crowded the other might not. For the later the civilian cannot predict what is the case in other floors or it is tedious to go around the place and check the free place for shopping. This is where IoT comes into picture. The proposed work detects the crowd in an indoor environment and display the density of crowd in the form of heat maps on an android application which the user can monitor from anywhere around the world. This application can also help the retailer to control the crowd based on the heat map results.

INTERNET OF THINGS

Connecting anything/object to internet can be referred to as the IoT. IoT is one of the booming technology since 2015. In the era of automation this IoT plays the most important role. With the help of IoTany objects can be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit**.**

The potentialities offered by the IoT make it possible to develop numerous applications based on it, of which only a few applications are currently deployed. In future, there will be smart applications for smarter homes and offices, smarter transportation systems, smarter hospitals, smarter enterprises and factories.

CHALLENGES INVOLVED IN IoT

The following key challenges exist in IoT:[]

In the domain of security the challenges are:

(a) securing the architecture of IOT system- security has to be ensured bothduring design time and execution time,
(b) Identification and protection of IOT from arbitrary attacks (e.g. DoS and DDoS attacks)
(c) Identification and protection of IOT from malicious software.

In the domain of user privacy, the specific challenges are:

(a) control over personal information (dataprivacy) and control over individuals physical location and movement (location privacy),

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(b) need for privacy enhancement technologies and relevant protection laws, and
(c) standards, methodologies and tools for identity management of users and objects.

In the domain of trust, some of the specific challenges are:

(a) Need for easy and natural exchange of critical, protected and sensitive data - e.g. smart objects will communicate on behalf of users / organizations with services they can trust, and
(b) trust has to be a part of the design of IoT and must be built in.
(c) Managing heterogeneity - managing heterogeneous applications, environments and devices constitute a major challenge.

In addition to the above major challenges, some of the other challenges are:

a) managing large amount of information and mining large volume of data to provide useful services,
b) designing an efficient architecture for sensor networking and storage,
c) designing mechanisms for sensor data discovery,
d) designing sensor data communication protocols - senor data query, publish/subscribe mechanisms,
e) developing sensor data stream processing mechanisms, and (vi) sensor data mining - correlation, aggregation filtering techniques design.

CROWD BEHAVIORAL UNDERSTANDING MODEL

The behavioral analysis of a crowd is an important topic of research in computer vision. In general, the temporal information is used to estimate the behavior of a crowd in a given environment, such as main directions [18], velocities [5], and unusual motions [13], [15], [17]. A great variety of approaches were proposed in past years to deal with crowd analysis and understanding that could involve researchers from several areas. The problem of validation is particularly challenging when dealing with crowded scenes, since ground-trothed video footages containing specific abnormal behaviors in denser crowds are not largely available. To overcome this problem, some authors [13], [2] have used crowd simulation algorithms to generate controlled situations with known ground truth to test their algorithms. In fact, concepts related to crowd simulation are also being explored to distinguish normal and abnormal behaviors, as in [15].

MATERIALS AND METHODS

Proposed System Architecture

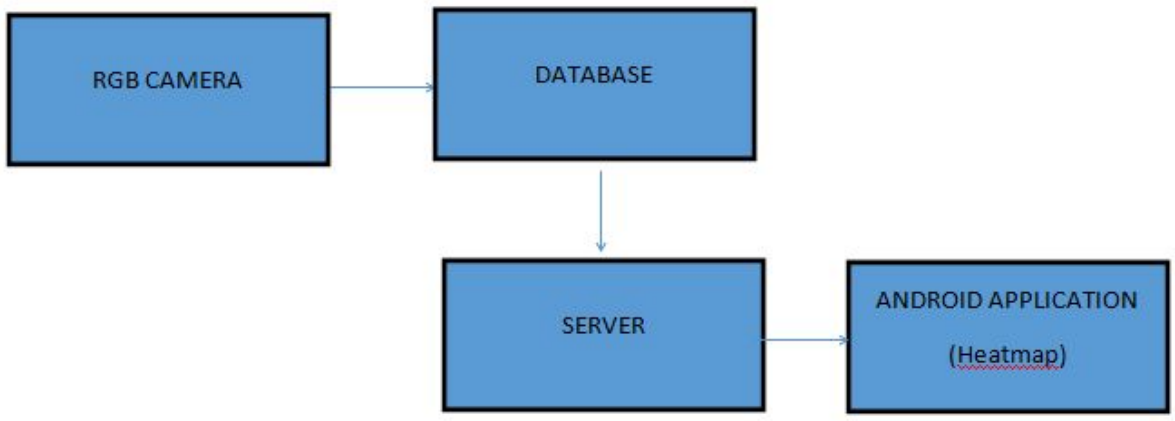

Fig 1.Proposed System Architecture

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In the indoor environment the RGB camera is which is deployed is used to capture the indoor environment without any civilians present. The captured image is stored in the database. Once this setup is deployed now the camera starts capturing the images for every 1 second time interval. The image captured is compared with the image already stored in database. The comparison is done by the SURF algorithm which is discussed in the following sub heads. The difference in two of the RGB image is calculated by the surf algorithm and it is sent to the server. The android application which is developed then fetches the newly generated image from the server and displays it in the form of a heat map.

Working Principle

1. Rgb Camera

A RGB camera is nothing but a camera with RGB view , where all the images are captured in RGB format.An RGB camera delivers the three basic color components (red, green, and blue) on three different wires. This type of camera often uses three independent CCD sensors to acquire the three color signals. RGB cameras are used for very accurate color image acquisitions.[1]

Fig 2 .RGB Camera

The fig.2 shows the RGB camera[18]. The RGB cameraconsists of an IR camera which captures the image using the infrared radiation rather than using the visible light. It has the RGBD sensor becauseof which the captured is in RGB format.

Fig 3.(From left) normal image & RGB representation of the same image

Fig.3 shows the difference between the normal camera captured image and the RGB camera captured image[17]

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2. *SURF Algorithm*

In computer vision SURF (Speeded Up Robust Features)[8] is a patented local feature detector and descriptor. It can be used for tasks such as object recognition , image detector , image registration and classification. It is partially similar to the SIFT(Scale invariant feature transform) algorithm. But SURF is said to be faster than the SIFT algorithm. It is mainly robust.
Three main parts of the SURF algorithm is

a. Insert point detection

Square shaping filters are used for approximation of Gaussian smoothing. Square filtering is much faster if we use integral image. Integral images are nothing but the image being divided into rectangular grids and the sum of the grid points are considered.

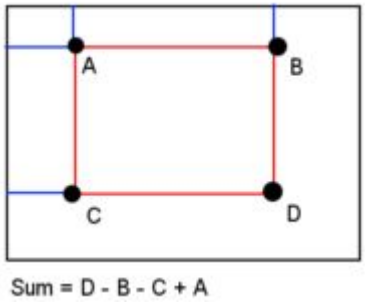

Fig 4.Rectangular grids on the RGB image

To find the point of interest it uses blob detector based on 'hessian matrix' to find points of interest.

$$\mathbf{H} = \begin{bmatrix} \frac{\partial^2 f}{\partial x_1^2} & \frac{\partial^2 f}{\partial x_1 \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_1 \partial x_n} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2^2} & \cdots & \frac{\partial^2 f}{\partial x_2 \partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 f}{\partial x_n \partial x_1} & \frac{\partial^2 f}{\partial x_n \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_n^2} \end{bmatrix}. \quad (1)$$

The determinant of the hessian matrix is used as a measure of local change around the point and points are chosen where the determinant is maximum[8].

b. Local neighborhood description

- Every point of interest points are given a description
- It gives a robust description

c. Matching

Matching is performed by comparing the descriptors.

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d. Advantages and disadvantages of SURF algorithm

The major advantages of the SURF algorithm[8] are it is fast,outperforms both in speed and accuracy,high reliability,high repeatability,quality of the resulting 3D model is high,real time computation without any loss in performance,matching is faster

The drawbacks are it performs worst under blur and affine changes situation,when rotation is large performance drops,no rotational invariance,poor matching rates,highly sensitive.

3. Heatmap

A heat map (or heatmap) is a graphical representation of data where the individual values contained in a matrix are represented as colors specifically in RGB.To create a heatmap first we need to create a grid. A grid is a structure (usually two-dimensional) made up of a series of intersecting straight mostly vertical and horizontal lines used to structure the content. As in indoor environment we cannot use GPS, which obviously means we cannot utilize longitude and latitude. The possible way is to use coordinate geometry. A grid should be created in equal length both horizontal and vertical. After creating grid we should interpolate the colors to detect the crowd. For instance Red color represents there is more crowd, Green represent medium crowd and blue color represent less crowd. The color is detected based on the intensity which is obtained from particular x & y coordinates i.e., from difference in the image generated after the comparison of the in the database. After getting start point (x1,y1) and end point(x2,y2) , the two points are interpolated to determine the place where the heatmap has to be represented in the floormap.

Interpolation = (2)

The Heatmap is generated according to the calculated interpolated value within the grid. By using this methodology each grid will generate different heatmap.

RESULTS AND DISCUSSION

In this paper real time RGB cameras are not used instead sample RGB images are obtained and stored in the data base. SURF algorithm is written on the server , which in turn performs the comparison of the images and stores the resulting difference of image in the database. Services are written to display the heatmap in the android application from the database. The below fig.5 displays the sample floor map which is used to display the heat map[19].

Fig 5.Sample floormap

The following images where used to compare and detect the crowd density. Fig.6 shows the environment with crowd which being represented in RGB image format[].

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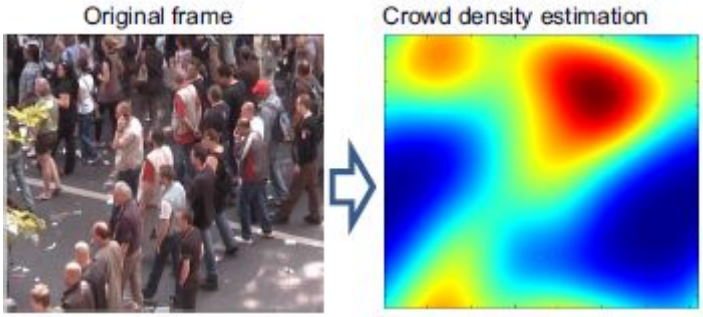

Fig 6 :Samplefloormap

Fig.7 shows the heatmap generated based on the density of crowd after being compared with the already stored image. The red colour represents the heavy crowded area in the environment, green represents the medium crowded and blue represents the less crowded area. The regenerate heatmap button is used to generate a new heat map on users demand i.e., it displays the currently updated crowd of the indoor environment.

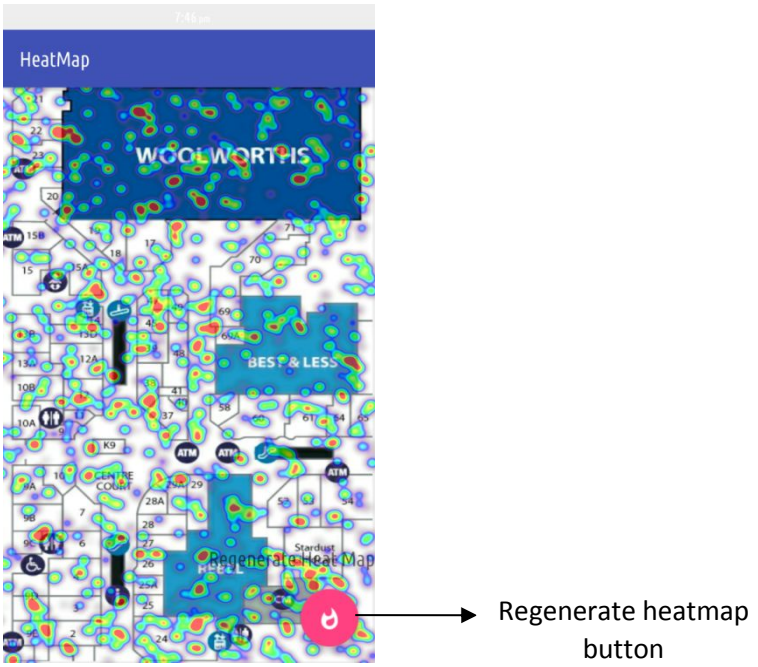

Fig 7.Heatmap generated on the floormap

CONCLUSION

In this paper the technique of crowd detection in an indoor environment has been proposed. The technique employs a RGB camera which captures the image in RGB format and uploads to the database. The existing stored image in database and the newly recorded image are compared using the SURF algorithm and the difference encountered in the image has been displayed in the form of heat map. As deploying RGB cameras require infrastructural changes and cost it was not used in this paper instead a sample RGB image was used to perform the process. For the future work the proposed technique has to be implemented with the real time RGB camera and entire experimental setup will be deployed in real time. The major challenge involved in using an RGB camera is care must be taken that there is no theft/hacking of the real time data that the camera is feeding into the server.

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