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Research on crowd gathering risk identification based on cell sensor and face recognition

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***Abstract*—The risks of crowd gathering which are often neglected may incur severe catastrophe. With the development of economics and technology, there has been more and more opportunity for people to get together. At the same time, significant progress has been made in the field of risk prevention, such as cell senor and face recognition. The paper presents an idea to count the number of pedestrians by making use of the cell sensor and adjust the number by using face recognition. Based on the result of cell sensor and face recognition, the paper proposes a framework about the measurement of the crowd density and avoidance of the risks of crowd gathering.**

Keywords-risks of crowd gathering; cell sensor; face recognition; LBP

I. INTRODUCTION

Recently, significant changes have taken place in every aspects of people's life, and the people can easily get together, such as a show, a game, a play and so on. As in Figure.1, it is the development of crowd gathering. For one thing, it is more likely to turn out to crowd even to stampede that takes people's lives. For example, in the last day of 2014 in Shanghai in China, a terrible disaster took place which took 39 peoples' life and turned 49 people. For another, benefited from efficacious management and advisable reaction, the crowd gathering is scattered successfully.

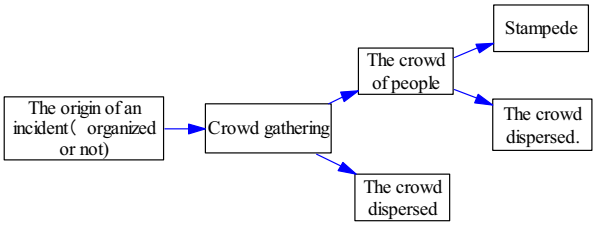

Figure 1 The development of crowd gathering

Many studies have been conducted to estimate the crowd density, Wang et al. (2012) [1], Xuefeng Li(2012) [2] calculate the crowd density based on the local binary pattern co-occurrence matrix. They pick up three local texture features and evaluate the crowd density which tells the different levels of crowd. Ghidoni et al. (2013) [3], Yan Li (2013) [4] calculate the crowd density according to co-occurrence matrix. More specifically, Ghidoni et al. make use of Adaboost and Bayesian algorithm, Yan Li (2013) combine local features with the whole ones. First, Yan Li processes the importing pictures and counts the proportion that foreground to the whole of the picture; Second, to pull in the threshold segmentation mechanism; Third, to evaluate the crowd density. Ge et al. (2012) [5] study the algorithm of the pedestrians' walk. Shaoet al. (2013) [6] take advantage of a multi-part local sparse appearance model to count the crowd density, Mazzon et al. (2012) [7] study a. person re-identification in crowd, they define the positions of the crowd according to reappearing modal. In Dimitrios Chrysostomou's [8] paper, the multi-camera system is employed to cover, monitor and improve the safety of people in large multifunctional crowded buildings. Zhiwei Wu (2012)[9] proposes a solution to evacuate based on the navigation and agent, which demonstrates the safety evacuation under different conditions. Wei Zhao (2014) [10] put forward a new method of evacuation and simulate the movement of individuals. It is clear that most of the literatures focus on the LBP and co-occurrence matrix. Nowadays, it is the tendency to make use of the high technology, such as multimedia, monitoring and so on. Depending on former reviews and risk management theory, this paper proposes an idea about how to analyze the risks of crowd gathering. It is a creative method to use cell sensor and face recognition to evaluate the crowd density.

II. METHODOLOGY

Great changes have taken place in all aspects of our life. Mobil phones are essential to everyone, not only to the majors but to children and elders. As is shown in ministry of industry and information technology of the People's Republic of China (MIIT), the holders of mobile telephones reach to 12.92 hundred million in China, which means that 94.53 people in 100 hold mobile phones. At the same time, it is popular to install monitors in public or personal regions. These monitors are clear and effective to help us to evaluate the crowd density.

There have been many literatures in which the cell senor and face recognition are introduced. Chen Xingpeng(2009) [12] seeks the active location methods how to locate mobile phone in emergency system. Zhang Yongchuan (2013) [13] creates the visualization analysis platform of user travel behavior based on ArcGIS and secondary development method. Xu Ning et.al (2014) [14] propose a home-work location identification method based on short-term, large-scale, and regularly sampled mobile phone tracking data. On face recognition, Li Gen (2014) [15] research face recognition based on local feature and

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evolutionary algorithm. Ma Xiaohu, et al (2014) [16] improve version of sparsely preserving projection (SPP) and proposes discriminant sparsity preserving embedding (DSPE) for face recognition. J.Y.Choi,Y.M.Ro (2009) [17], B.Li(2010) [18],Wang Zhifei (2013) [19]study face recognition according to different algorithms due to its great potential applications. According to these literatures, it is possible in theory to make use of the cell senor and face recognition to count the individuals.

So the methodology of this paper is to count the individuals according to cell sensor and adjust the numbers by face recognition. As is described in Figure 2, it is the mean of the two methods. Then this paper analyzes the risks of the crowd gathering and prevents from stampedes as far as possible.

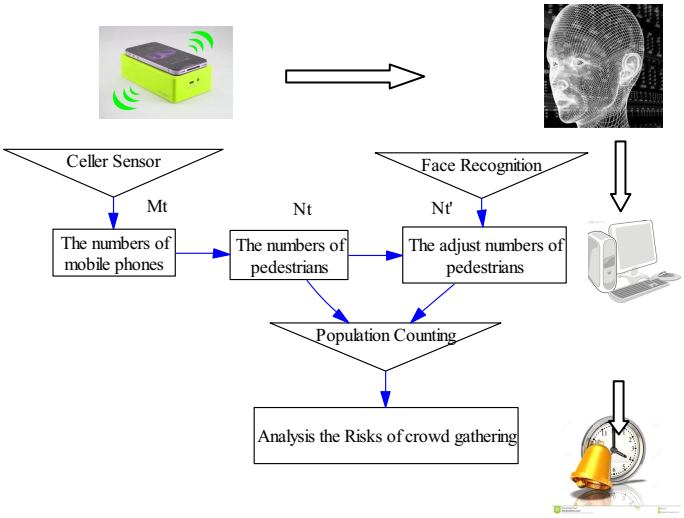

Figure 2 Analysis of Risks of crowd gathering

III. POPULATION COUNTING BY CELL SENSOR

Population Counting by cell sensor is to count the number of the individuals by making use of the technical device, which can count the number of the mobile phones whether they are working or not. Then this paper speculates the number of the people based on the phones' number. The probability is as follows.

First, in China, the rate of the mobile phones' holders is more than 90%. In public, almost everyone have a mobile phone. As is known in the database of MIIT [20], the second quarter of 2015, the rate of spread of mobile phones reach to 94.5 per hundred peoples in China, In the city of Beijing, the rate of them is nearly 200 per hundred peoples, in the provinces of Guangdong, Shanghai, Zhejiang, Fujian, Liaoning, Jiangsu, Ningxia and Hainan, the rates are more than 100 per hundred peoples. As is shown in Figure.3 in 2014, it is obvious relational between the population and holders of mobile phones of each province. It is rational to evaluate the numbers of individuals according to the mobile phones' numbers.

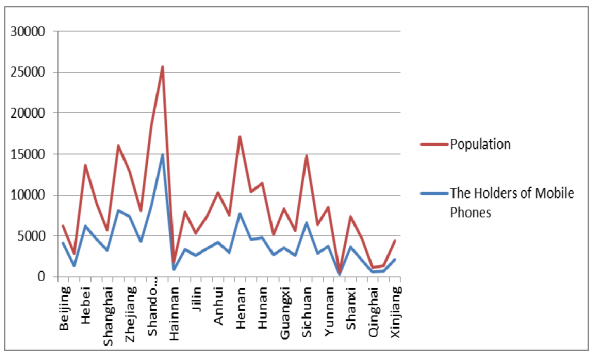

Figure 3 The population and the holders of mobile phones of different provinces in China in 2014[20]

Second, the cell sensor devices are variety and powerful so that they can probe into the different level of frequencies and wave bands, such as GSM, CDMA and 3G. It is easy to distinguish if the mobile phone is in sleep mode or not. The detection zone is within a 3-mile radius.

The cell sensor does have some advantages as follows. First, it is easy to work. To gain the widest market, the manufacturing company makes the cell sensor devices simple to use. Second, the computing process is easy. In short time, the cell sensor device can compute the numbers quickly and clearly. Third, the installing cost is very cheap, for it is portable. However, it is not perfect. For example, affected by the signal interfering, the numbers of the mobile phones may not accurate. Moreover, the numbers of the population and the numbers of the mobile phones are not exactly equal, which are affected by the ages, material conditions and so on. On that basis, this paper adjusts the result by face recognition.

IV. POPULATION COUNTING BY FACE RECOGNITION

Face recognition is a biologic identification technology, which confirms the identity according to the facial features. This method takes the pictures from the camera equipment, deals with the pictures based on the face features. [20] The prerequisites of this method are as follows.

First, the numbers of the entrances and exits are fixed no matter whether indoors or outdoors, and the monitor cameras are installed.

Second, the pictures which are got from the cameras are high-definition and can reflect the action of the pedestrians.

Third, the acreage that the camera screens is fixed which means the acreage in advance can be calculated.

Different from the artificial counting, this method is based on the face recognition which evaluates the crowd density by computer image processing technology. Local Binary Pattern (LBP) is regular method which is proposed by T.Ojala and based on the texture features. [21]

Based on the theory of LBP, as is seen in Figure 4, assume that a picture about a scenario can be divided into 9

(3*3) districts. According to gray value of the picture, the characteristic value can be got and the central area's sum of gray value of pixels can be named for threshold (Figure 4-a). To compare the threshold (30 in Figure 4-b) with the neighborhoods (8 in all) (Figure 4-b), the value can be calculated. If the value is bigger than the threshold, it will be set for 1. Otherwise, it can be set for 0. As is shown in Figure 4-a, 45 is bigger than 30, it will be set for 1.However, 20 is smaller than 35, it will be set for 0. Then, all the neighborhoods are clockwise arrangement, and then an alignment can be got, which is the LBP feature. As is shown in Figure 4-c, the alignment is 10100100.

The formula of LBP features are as follows:

$$f(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0 \end{cases} \quad (1)$$

$$LBP(Xa) = \sum_{i=1}^{p-1} f(Ii - Ic) \times 2^i \quad (2)$$

Ic is central area's sum of gray value of pixels, *Ii* is the neighborhoods' sum of gray value of pixels. In Figure.4, *Ic* is 30,*Ii* are 45,20,45,10,15,37,23,12,p=9,according to calculating, LBP is 74, which means that the 8 neighborhoods' LBP features are 74.

Then, it is easy to get two pictures per 2 seconds according to the camera and compare them. In theory, based on LBP and C program, the number of people and crowd density can be got.

V. THE EVALUATION OF CROWD DENSITY AND THE RISKS OF THE CROWD GATHERING

A. *The evaluation of crowd density*

The steps of the evaluation of crowd density are as follows.

a) First, count the numbers of the mobile phones in the limited district. Based on the phones' numbers, evaluate the numbers of pedestrians. In particular, almost everyone have mobile phones, so it is easy to speculate the numbers of pedestrians according to the numbers of the mobile phones. The formula is as follow.

$$N_t = \gamma \times M_t \quad (3)$$

N_t is the numbers of pedestrians at the time t in the limited district , M_t means the numbers of mobile phones at the time t in the limited district, γ is the revise coefficient.

Obviously, it is the positive relational between the numbers of the people and the mobile phones. Generally speaking, γ>0, and the value of γ is affected by the ages, profession and so on. As in Figure.4,based on the average of the holders of the mobile phones in China, γ=1.058 , based on the average of the holders of the mobile phones in Beijing in the second quarter in 2015, γ=0.5. In this paper, if the value of γ is1, it means each one has a mobile phone.

Second, get pictures from the camera and make it to face recognition. Then, count the numbers of the pedestrians by face recognition at the same time in the same district with the cell sensor. The numbers of the pedestrians are named for N_t' .

Finally, get the average value of N_t and N_t' , according to combining the two algorithms. Then the crowd density can be calculated.

B. *The risks of the crowd gathering*

The risks of the crowd gathering are the risks caused by gathering of people, which may bring about stampedes. It should be attached importance on the management in public. This paper finds out the causes of the risks of crowd gathering and avoids risks. In the classical risks management theory, the rate of risks is the probability multiply by the loss of the risks.

Qingsong Zhang(2007) [22], Qingsong Zhang(2008) [23], Ruipeg Tong(2013) [24] propose the model to evaluate the risks of the crowd. As is summarized in their research, the risks of the crowd are the product of the trigger factor, rate of the retarding people and the deaths. Based on the risks management theory, this paper evaluates the risks according to the rate of the retarding people in limited district.

Here find out the factors of the risks according to the information got from camera equipment. To analyze the data from the camera equipment, combine the cell sensor and face recognition to study the main risks factors. These factors are as follows.

First, the speed of the pedestrians does have effect on the risks of crowd gathering.

According to the pictures which obtained by different cameras, the speed can be computed because the time and the distance are known. Based on the LBP, it is important to compare the two pictures and estimate the risks. Generally speaking, the faster the pedestrian walk, the less the numbers of people stranded and the easier to escape from the crowd. But when the speed is more than a certain speed, it is easy to fall and improve the risks of crowd gathering.

Second, the path of the pedestrians does have effect on the risks of crowd gathering.

It is important to research the path of the pedestrians. To get the pictures along different directions in limited district, this paper studies if the path of the pedestrians affects the risks of the crowd gathering. Generally speaking, if the pedestrians have the same path, the risks of crowd gathering are small; if they have different paths, it is easier to be accident.

Third, the obstacle does have effect on the risks of crowd gathering.

The obstacle in the region mainly refers to the objective environment, such as stairs, roughness, dark light, etc. The existence of obstacles, especially in which the pedestrians neglect, is easy to lead to the fall, even stampede. So it is necessary to remind the pedestrians of the obstacle.

VI. CONCLUSIONS

This paper analyzes the crowd density and the risks of the crowd gathering by using the idea to use both cell sensor and computer video, and taking advantage of artificial intelligence technology. It creates a design on cell sensor and face recognition based on local binary pattern (LBP) and risks management theory. The biggest feature is the integration of two kinds of high-tech methods to evaluate the crowd density. Moreover, based on the pictures obtained from the cameras, the paper analyzes the impact of the speed, the path and regional barriers to the crowd gathering risks.

The method also needs to be improved and optimized from the following aspects. On the one hand, based on the LBP theory of cell sensor and face recognition, it is difficult to be precise because the background is complex. On the other hand, it is hoped that the method of real test can be used in the future study to make full use of the artificial intelligence method.

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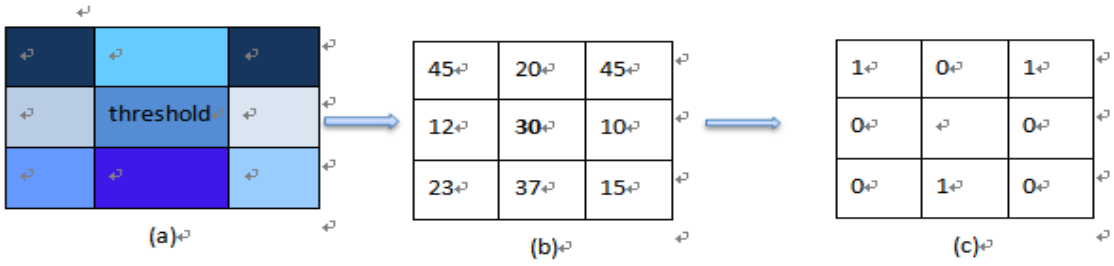

Figure 4 LBP Features