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Crowd Analysis using Computer Vision Techniques

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***Abstract*— Crowd analysis involves the interpretation of data gained studying the natural movement of groups or objects. Crowd analysis presents a survey using computer vision techniques covering different aspects such as people tracking, crowd density estimation, event detection, validation, and simulation. It also has wide range of applications such as crowd management, public space design, virtual environment, visual surveillance and intelligent environment. The major challenge in crowd analysis is the generation of ground thruthed images or video sequences, which can be used either for training or validation purposes.**

***Keywords*— Crowd analysis, tracking, crowd density, crowd synthesis.**

I. INTRODUCTION

Crowd is a large group of people gathered. The terms of crowd or known as 'mob' or 'mob rule' can be define as a collective characteristic such as 'an angry crowd', a peaceful crowd', and 'a panic crowd' are well accepted. Crowd is made up of the independent individual's parts, whereby each of them have their own objectives and behavior pattern which differ from the expected individually from its participants. Crowd may be structured or unstructured. Currently there are commercial systems are developed to track , recognize and understand the behavior of great variety of objects using one or more multiple video cameras, processing the information in one or more computers. Crowd analysis involves the interpretation of data gained by studying the natural movements of groups or objects.

A. Real world applications

Crowd management

In mass gatherings such as music festivals and sports events, crowded scene analysis can be used to develop crowd management strategies and assist the movement of the crowd or individuals, to avoid the crowd disasters and ensure the public safety [1].

Visual surveillance Many places of security interests such as railway station and shopping mall are very crowded. Conventional surveillance system may fail for high density of objects, regarding both accuracy and computation. We can leverage the results of crowd behavior analysis to crowd flux statistics and congestion analysis , anomaly detection and alarming etc[1].

Public space design

The analysis of crowd dynamics and its relevant findings can provide some guidelines for public space design, and therefore increase the efficiency and safety of train stations, airport terminals, theaters, public buildings, and mass events in the future[1].

Intelligent environment: Intelligent environment can be used to make a decision on how to split a crowd in a museum, based on their behaviour[2].

Virtual environment

Virtual environment can be used to validate or increase the use of mathematical models used in crowd simulation[2].

B. Problem and motivation

Problem: Video analysis and scene understanding usually involve object detection, tracking and behavior recognition [1]. For crowded scenes, without special considerations the conventional methods are not appropriate because of occlusions and ambiguities[1]. An important problem related to crowd analysis using computer vision is validation when dealing with crowded scenes. In a crowded situations ,it is difficult to segment and track accurately each individual, due to severe occlusions[2]. Estimating a crowd's density is also used for management and control. This can become more difficult when the subjects in the crowd are self-occluding[4].

Motivation: in crowded scene analysis the specific crowd behaviors needed to be detected and classified may be both rare and subtle[1].The goal of crowd analysis techniques based on the computer vision is to extract some kind of information from crowded video sequences that could be used to benefit a large number of applications[2]. Automated techniques are used for monitoring crowds such as estimating crowd density, tracking in crowd's movement is necessary[4].

C. Organization of the paper

The remainder of this paper is organized as follows. Section II describes literature survey, section III describes taxonomy of crowd analysis. In section IV describes features of crowd analysis, section V describes use cases of people counter, section VI contains conclusion of this paper.

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II . LITERATURE SURVEY

The background knowledge and the available features related to crowded scenes. Then, existing models, popular algorithms, evaluation protocols, as well as system performance are provided corresponding to different aspects of crowded scene analysis [1]. Presented a survey on crowd analysis using computer vision. This work tackles three important problems in crowd analysis: people counting/density estimation ,tracking in crowd scene , crowd behavior understanding in higher level analysis[2]. Use cases of people counter [3]. Three different ways to measure the crowd density in an outdoor scene by computer vision: Grey Level Dependancy matrix and Minkowski Fractal Dimension and the new method called as Translation Invariant Orthonormal Chebyshev Moments was also evaluated[4]. Presented a review study on people counting and crowd density estimation methods for surveillance based on computer vision by using two main different approaches: direct and indirect approaches [5].This paper presents some image processing techniques which, using existing closed-circuit television systems, can support both data collection and on-line monitoring of crowds. The application of these methods could lead to a better understanding of crowd behaviour, improved design of the built environment and increased pedestrian safety[6]. Taxonomy of the common approach of the crowd analysis [7]. New crowd density estimation approach including foreground detection and feature extraction [8]. A method for detecting an abnormality in crowd scenes based on crowd characterstics that includes crowd kinetic energy and motion direction. This approach estimates Crowd kinetic energy and motion direction based on the optical flow technique. Presented an approach to estimate the abnormality of crowd scene using static abnormality and dynamic abnormality[9]. video analytics can benefit from recent development in computer vision research for intent profiling, non-trajectory based representation in crowded scene analysis[10]. Image processing technique used is the edge detection technique where the edges of the object is detected[11].

III . TAXONOMY OF CROWD ANALYSIS

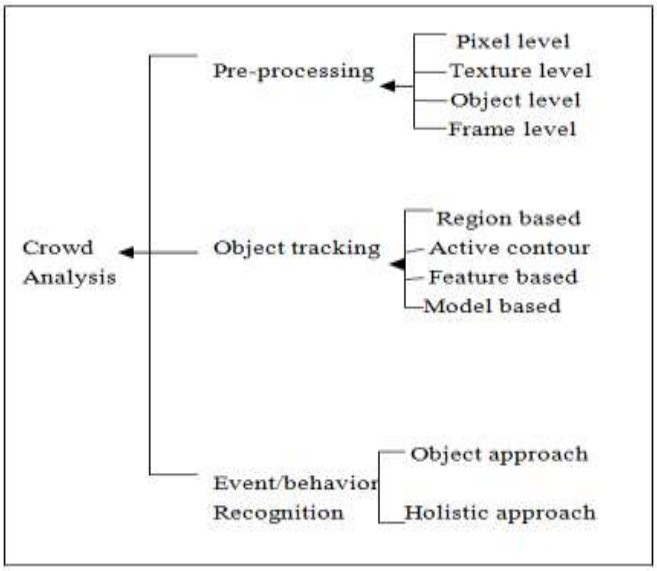

Figure 1: Taxonomy of crowd analysis

Pre-processing

Pixel level analysis:

Pixel-based analysis depends on very local features to estimate the number of people in a crowd scene. Because this method utilizes low- level features, most of the pixel-based methods are focused on crowd density estimation rather than identifying individuals. Most of these techniques use a removal background technique as the first step, for example, background subtraction is used only on reference image or automatic background generator to get artificial back ground image.

Texture level analysis

Texture level analysis explores high level features when compared to pixel based approaches, it is also mostly used to estimate the number of people in scene rather than identifying individuals. The images of dense crowds tend to present fine textures, while images of low density crowds tend to present coarse texture.

Object level analysis

Methods that rely on object level analysis try to identify individuals objects in scene. They tend to produce more accurate information when compared to pixel level analysis or texture level analysis, but identifying individuals in a single image or a video sequence is mostly feasible in lower

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density crowds. In denser crowds, clutter and severe occlusions make the individual counting problem almost impossible to solve.

Frame level analysis

Frame level analysis model behaviors of full scene within the field of view of a camera.

Object tracking

Object tracking in a crowd attempt to minimizing the constraint such as occlusion, color intensity , illumination condition, appearance and etc.

Region based approach

Region based approach is a robust computer vision in unconstrained crowd scene which is the information such as density, direction and velocity is extracted using optical flow technique. Optical flow is to compute pixel-wise instantaneous motion between consecutive frames . Optical flow is robust to multiple and simultaneous camera and object motions, and it is widely used in crowd motion detection and segmentation.

Active contour based approach

Active contour based approach is used to model the target partial occlusions and to extent some noise. Typically has been used a color histogram, however the weaknesses by using this technique is hardly change the color histogram when impair with similar object such as head in a crowd.

Feature based approach

Feature based approach is presented in feature image by d describing the blob level feature. The examples are size, shape, elongatedness, luminance histogram and displacement histogram.

Model based approach

Model based approach can solve blob merge and split constraint. This approach is used to segment and track multiple people occlusion. Bottom up image analysis is used to improve efficiency in computer vision.

Event/behavior recognition

Another important process in a crowd analysis is event/behavior recognition. It can be characterized by regular motion patterns such as direction, speed, etc. Monitoring and modelling the crowd is not so much to analyze normal crowd behavior, but to detect something different behavior from it. These are referred to as anomalous or abnormal.

Object based approach

A crowd is analyzes by treating collection of individual to estimate the velocities , direction and abnormal motion. The complexity occur when the occlusion exist that may affect the process of analyzing such as detection of object, tracking trajectories and recognizing the activities in a dense crowd. Two approaches called as feature correlation and binary function. Feature correlation is used to position of center of the head while binary head is defined to represent the distance between the agents.

Holistic based approach

A crowd is analyzes by treating a single entity to estimate the velocities, direction and abnormal motion. The analysis covers medium to high density scene in global entity. However using holistic approach application is still having a weakness because in the dense crowd image of the object have a low resolution and consists of static and dynamic occlusions. Thus, to get more accurate estimation parameter, object based approach is better.

IV. FEATURES OF CROWD ANALYSIS

Anonymity
Narrow Attention
Suggestibility
Emotional
Irresponsibility

Anonymity

Crowds are anonymous, both because they are large and because they are temporary. A crowd usually consists of relatively large number of people. The members of crowd do not know each other. They do not pay any attention to other members as individuals.

Narrow Attention

The crowd is devoid of a wide attention. It directs its attention only to one or two things at a time.

Suggestibility

The members of the crowd are not open to conviction. They do not tolerate any opposition to their views, rather any opposition enrages them.

Emotional

The members of crowd are highly emotional. They respond not only to the emotional situations but also to the emotions of the other members of the crowd. Some members of the crowd get excited because because other members are excited.

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Irresponsibility
A crowd in action can be terrifying thing. The sense of responsibility always controls individuals disappears entirely in crowd. The college students burn buses in a strike, the crowd behavior deviates from normal behavior which is supported by the other members of the crowd.

V . PEOPLE COUNTER

A Use Cases

Retail stores
Conversion rate : people counters are used in retail stores for calculating the conversion rate i.e, total number of visitors by the number that make purchases.
Marketing effectiveness : Shopping mall marketing professionals rely on visitor statistics to measure the effectiveness of the current marketing campaign. Often, shopping mall owners measure marketing effectiveness with the same conversion rate as retail stores.

Shopping Malls
Monitoring of High-Traffic Areas: people counters are used in Shopping centers for measuring the number of visitors in a given area. People counters also assist in measuring the areas where people tend to congregate, the areas where people tend to gather are often charged higher rent.

Museums and libraries
Funding Justification: Non-profit organizations often use visitor counts as evidence when applying for grants or other financial aid, when planning for seasonal staffing, or other strategic operational decisions. In cases where tickets are not sold, such as in museums and libraries, counting is either automated or staff keep a log of how many clients use different services.

Stadiums
Crowd Management: People counters are used to measure the traffic flows of events; traffic patterns are used to improve traffic flow, particularly when large crowds are entering and exiting the stadium.

Smart Office buildings
Fire Management: In the case of fire, people counters can be used to approximate the number of people inside the building.

B Technologies

Many different technologies are used in people counting devices, such as infrared beams, thermal imaging, computer vision, and WiFi counting.

1st Generation: Infrared Beam Counters
The simplest form of counter is a single, horizontal infrared beam across an entrance which is typically linked to a small LCD display unit at the side of the doorway. Such a beam counts a 'tick' when the beam is broken, therefore it is normal to divide the 'ticks' by two to get visitor Numbers.

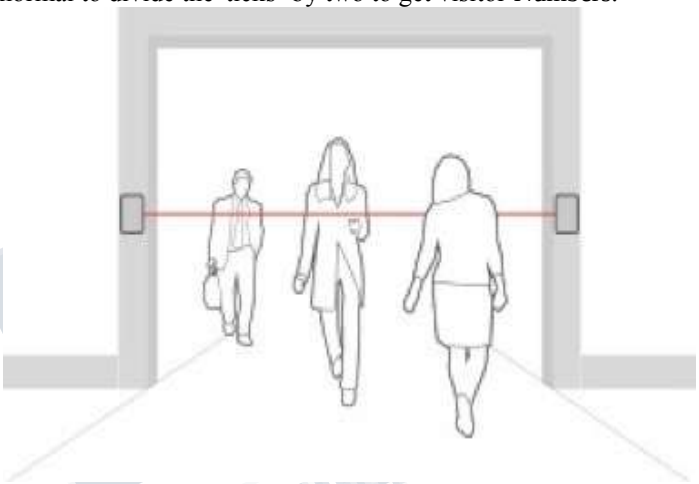

Figure 2: The simplest form of counter is a single, horizontal infrared beam across an entrance which counts when a person or object passes and breaks its beam.

2nd Generation: Thermal counters
Thermal imaging systems use array sensors that detect heat sources. These systems are typically implemented using embedded technology and are mounted overhead for high accuracy.

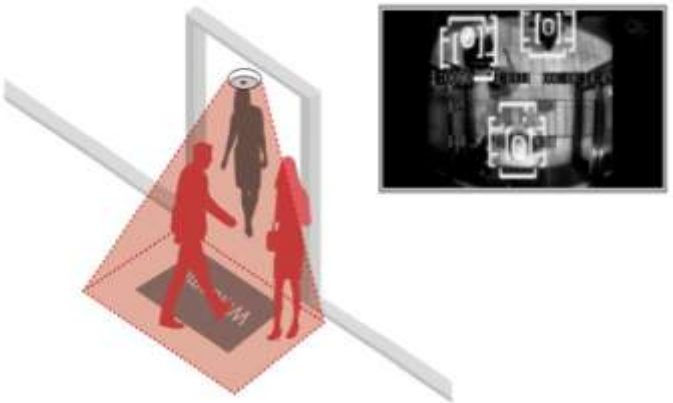

Figure 3: Thermal counters

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They do have limitations, such as:
1. Thermal counters cannot be mounted on a high ceiling
2. Thermal counters can only cover a narrow door entrance
3. It is difficult to verify the accuracy of the counter
4. Accuracy is reduced in places with slight variations in thermal conditions.

3rd Generation: Video & WiFi counting

There are two types of 3rd Generation People Counters. Video counters use complex algorithms perform counting using camera imaging by counting the number of people directly from video tape. Wi-Fi Counting functionality collects WiFi probe request signals from shoppers smartphones, allowing data to be collected on those not in the store.

Video Counting

Computer vision works via an embedded device, reducing the network bandwidth usage, as only the number of people must be sent over the network. Adaptive algorithms have been developed to provide accurate counting for both outdoor and indoor counting using video counting.

Wi-Fi Counting

Wi-Fi Counting uses a WiFi receiver to pick up unique WiFi management frames emitted from Smartphone within range. While not all people carry a smart phone , Wi-Fi counting can produce statistically significant metrics with a large enough sample size.

VI. CONCLUSION

Crowd analysis involves the interpretation of data gained by studying the natural movements of groups or objects. It also has wide range of applications such as crowd management, public space design, virtual environment, visual surveillance and intelligent environment.

Crowd analysis can be done by using three methods 1. Pre-processing 2.Object tracking 3.Event/behaviour recognition. People counter is a device that is used to measure the number of people traversing a certain passage or entrance. In the 1st generation, infrared beam counters are used. In the 2nd generation, thermal counters are used that detect heat sources from the human body. In the 3rd generation, video counting and wifi counting are used.

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