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A Review on Pedestrian Movement Direction Recognition System

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Abstract: Pedestrian movement direction recognition is an important factor in the case of autonomous driver assistance and security surveillance systems. Pedestrians are the crucial moving objects in streets, roads, and events, where thousands of people may gather. People flow analysis on zebra crossings and in shopping centres is an important element to improve safety and to enable autonomous cars to drive in real life environments. The proposed system is based on deep learning techniques such as convolutional neural networks (CNN) to achieve a reliable detection of pedestrians moving in a particular direction. And also a CNN- based technique that improves the current pedestrian detection techniques such as histograms of oriented gradients, linear SVM. It is used to generate a sum of subtracted frames and flow estimation around the detected pedestrian. Which are used as an input for the proposed modified CNN network. By using conventional techniques the efficiency and performance of the system will be declined. In order to avoid this drawback we are using high performance CNN technology. In this paper we have consolidated such recent techniques and its unique features. The survey done provides different approaches for detecting pedestrians and the parameters considered for same. Discussion is also made on various Databases.

Keywords: Pedestrian detection, advance driver assistance System, convolutional neural networks

I. INTRODUCTION

This Pedestrians account for 22% of the worldwide 1.24 million deaths caused by tra c accidents every year [1]. Most of these deaths occur when pedestrians are crossing a street [2] at sunset [1] and may be caused by poor visibility and drivers' fatigue. Many researchers have focused on the development of algorithms that estimate pedestrians' intentions of crossing street [3]. However, the problem is still challenging, since pedestrians can move in any direction and suddenly change motion [4].An important stream of research within computer vision which has gained a large amount of importance in the last few years is the understanding of human activity from a video. Understanding human activity applications in various fields includes surveillance. Character animation, teleconferencing, advanced intelligent user interfaces, biomechanical analysis of actions for sports and medicine, etc are the other applications. Before the understanding of the human complexity activity, we need automatic methods for finding humans in an image or a video. Once the human is detected, depending on the application, the system can do further processing to go into the details of understanding the human activity. This paper selects different sample papers from the broad literature on human detection, and presents a review and classification of the various methods. It does not deal with specialized domains such as detection of faces, gestures or characterizing human activity, each of which possess an extensive literature of their own.

Pedestrian detection has been one of the greatest studied problems in computer vision. One reason is that pedestrian detection is the first step for a number of applications such as smart video surveillance, people-finding for military applications, human-robot interaction, intelligent digital management, and Autonomous Driver Assistance Systems (ADAS). And also random movements of pedestrians and

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also vehicles in the traffic environments make it necessary to develop people flow analysis and movement intention recognition systems. In recent years, Convolutional Neural Networks (CNN) and other deep learning techniques have shown impressive performance in many computer vision problems so that it could be the perfect approach in order to reduce the traffic related problems. By using a suitable hardware system, the proposed model can implement in various applications. In this proposed model, the main objective is to detect and recognize the pedestrian intention on streets, zebra crossings or road junctions, so as to be able to alert drivers or monitoring systems about possible risk situations. The objectives of this paper are to review the research papers related to pedestrian detection in order to provide an overview of the recent developments related to research pedestrian detection.

II. Related Works

Mainly this paper is divided into three stages: input, process and output, to facilitate discussion and understanding of the process of pedestrian detection. Figure 2 illustrates the process of pedestrian detection. In the input process, includes the various camera sections like single camera or multiple type.Once the data are received from the input device, is then processed using specific algorithm and techniques. In general, pre-processing will be done in advance to ensure the quality of incoming data. After checking the quality of the inputs the next step of determining the region of interest (ROI) and object segmentation are two processes that plays an important role in the pedestrian detection process. Lot of techniques and algorithms widely researched to optimize this process. Object classification techniques are the last part in the case of process section. Examples of object classification algorithm that is widely used is the Support Vector Machine (SVM) [5] and neural networks [2].

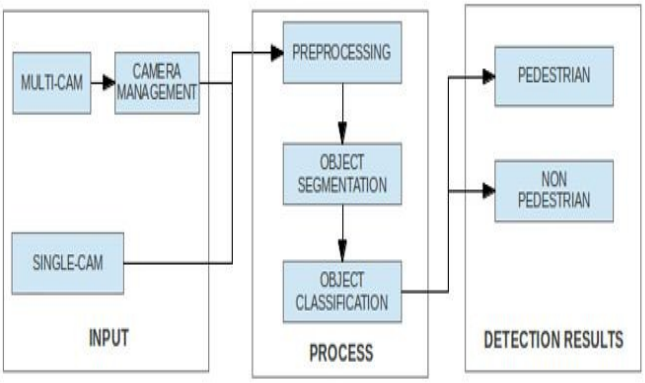

Fig. 1. Pedestrian Detection Process

A. INPUT DEVICES

As explained in the former section, the type of input device used in pedestrian detection process, there are some devices that had been tried such as laser scanner sensors, thermal sensors, video cameras, PTZ cameras and infrared cameras. Several researches using single laser scanner sensors [7] and multiple laser sensors [8]. Meanwhile, the research of used far infrared sensors that can detect objects in low resolution (long distance) as well as colour and texture are less clear. For an environment with poor lighting, such as at night, often used stereo cameras that have night vision features [9]. Initially, feature based methods were applied for the detection of pedestrians.

B. DATASETS

In some pedestrian detection methods, training and testing data are needed to test the performance of a method or algorithm. Currently, many people provide training and testing data (often called a dataset) and can be downloaded for free. Dollar et al. [10] summarizes some of the datasets are freely available and at the same time publish a more comprehensive datasets, Caltech Pedestrian dataset. Ahad in [11] also summarizes the various datasets associated with action recognition on video. Ahad divides the datasets into tree categories: person dataset as a single object, movement of body parts and social interaction between objects. Table 1 provide some datasets is based on the results of Dollar et al. [10] research, Ahad et al. [11] and some other papers.

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Datasets	Pedestrian	Negative images	Positive images	Year
INRIA[12]	1208	1218	614	2005
ETH[13]	2388	-	499	2007
TUD-det[14]	400	-	400	2008
TUD-Brussels[15]	1776	218	1092	2009
Daimler DB[16]	15.6K	6.7K	-	2009
Caltech[17]	192K	61K	67K	2009
CVC[18]	2534	7650	1016	2007-2010

Table .1: Dataset

C. DETECTION PROCESS

Once the video data captured from the camera, pre-processing step will carried out.. It is mainly for normalization and calibration of the input, so the next process can take place properly. This paper divides the pedestrian detection process into two groups, offline detection process and real-time detection process. Offline detection process uses the data input in the form of video or a set of images which is obtained from a separate input device. The input data is processed manually. And in the case of real time detection process, the video data is captured directly and in real-time through input devices such as cameras, CCTV or other sensors. Challenges in the process of real-time pedestrian detection are all to be done automatically by the system, so it required detection method that relies on speed.

Several studies in real-time pedestrian detection as in [19] . After the pre-processing stage, the further stage is object segmentation or segmenting the ROI (region of interest). Segmentation of the objects from the background or other objects is an important step in the process of pedestrian detection. The better object segmentation process will result in a high level of accuracy as well. The simplest and fast segmentation process is background subtraction techniques as in the study [20]. However, the background subtraction techniques have disadvantages when applied to dynamic environments. In a dynamic environment, the background can change suddenly because of various factors. But it weakness can be overcome by adaptive background subtraction techniques [21]. In adaptive method, the background is determined adaptively and adjusts environmental conditions. It is resulted in the detection process becomes slower than the static background subtraction because computation performed continuously for every frame in the video.

Method & Year of Publication	Feature	Classifier	Result
FPDW(2010)	HOG	VJ detector	FPPI -37.5%
Non-background HOG(2012)	HOG	Linear SVM	Better and faster
HOG-SVM Light(2013)	HOG	SVM	MR -70%
LBP-HOG(2013)	HOG,LBP	SVM	FPPI -78%
HOG+BA(2013)	HOG	Linear SVM	Speed 0.31 s/frame
CHOG-DOD(2014)	Cell based HOG	Linear SVM	21.24 time/frame
VDM-MP(2014)	Mixture of DPM	Fast based classifier	FPPI-50.4%
Fast Feature pyramid(2014)	Multi-scale HOG	Adaboost	MR-40%
Cascaded 2 layer(2014)	Part based HOG	Linear SVM	More better than full body based
DTM(2014)	Part based HOG	Coarse to fine SVM	FPPI-74%

Table .2 : Features and classifier efficiency

From above, it is clear that any of the object segmentation method requires the separation of background first. Several studies are there to segment and classify objects by extracting certain features in the image. Examples of features used are HOG [22] and optical flow [23]. Table 2 offers the various methods of pedestrian detection. Histograms of Oriented Gradient (HOG) are the most widely used features for pedestrian detection. It is also a proven accurate feature for pedestrian detection process both in image and video. HOG method originally proposed by Dalal and Triggs [22]. Also, many researchers do modifications HOG method to improve the level of accuracy and speed. Table 2 presents some pedestrian detection methods that apply the HOG method. Other studies have suggested a new method of Gaussian Particle Swarm Optimization (Gaussian- PSO), and HOG-based detection technique with the capability to more quickly and accurately. One of the recent studies related to pedestrian detection proposed CHOG-DOD method [24]. This method dominates the previous methods were HOG features are computed based on the image blocks. In a cell-based HOG (CHOG) algorithm, the features in one cell are not shared with overlapping blocks. To upturn the speed of the detection process, feature extraction through distributed to multiple frames at once. In other words, the process of feature extraction and classification is dispersed in the current frame and several earlier frames.

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The process is tested by INRIA dataset and use SVM classification algorithm. It has a speed of up to 21.24 times per frame, and it only requires a 252-dimensional features vector. There is much smaller dimension than the BHOG method [25] which requires 3780-dimensional feature vectors. If Some pedestrian detection methods are utilizing the shape features of the object. One of them is the Shape Context method that perform matching and object recognition based on shape [26] . Furthermore, the method is also developed in [27] for infrared images. The method is known as ISC (Improved Shape Context). The results disclosed that the method is suitable to be applied to the infrared image. Related with the method using HOG feature, ISC method has better accuracy rate of 4.95%. Classification is part of the pedestrian detection process that very significant. Classification algorithm will categorize the extracted features into several classes. SVM (Support Vector Machine) classification is the most widely used detection method. In Table 2; there are several papers that use the SVM classification method and its derivatives. SVM is one technique that can be used to carry out data classification and prediction. This method is fixed in statistical learning theory that the results are quite good when compared to other methods. The main norm of this technique is to find the function of separator (classifier) that is optimal to separate the data in a different class. In the neural network techniques, all training data to be learned throughout the training process, and then the SVM is only a number of selected data are included in the training process. It is the leftover of the SVM because not all training data to be included so that the process will be faster. In addition to pedestrian detection method based on the shape of the object, a method based on the movement in the video is also quite effective and broadly studied. The method is fairly accurate and potential because pedestrian movement has its specificity. Deviations in sequential movements can be detected and predicted, although irregular movements may still occur. The study of [28] using statistics on the movement of objects and HOG feature selection techniques for detecting pedestrians. Bayes classification method is also used to upsurge the speed in the study. The results are good enough to achieve object detection in environments where pedestrian are quite close to the camera. From table 2 we can analyse the various features and classifiers.

D. PEDESTRIAN INTENSION ESTIMATION

The estimation of pedestrians' intention is even more challenging due to uncertainties regarding their impending motion [4]. In a fraction of a second, pedestrians can decide to move in one of many different possible directions, stop walking abruptly [29] have their image/point cloud occluded by a range of obstacles ,and be distracted talking to other pedestrians or even on a mobile phone. According to [30], the analysis of non-critical situations has not received considerable attention and Quintero et al., [31], observed the di erence between an e ective and a non-e ective intervention can depend merely on a few centimetres or a fraction of a second. fter realizing the advantages and better performance of Convolutional Neural Network (CNN), these were applied for the detection purposes with high performance results. Architectures like AlexNet[34] and Google Net [33]reduced the errors in the image net challenge by record levels. ConvNet [35] uses a mix of unsupervised and supervised training to create a deep convolutional neural network trained on INRIA pedestrian dataset. Because convolutional neural networks are new concept, their application to pedestrian detection and recognition is still in it's infancy. Table 3 shows the advantages and disadvantages of various classification methods including the proposed method. The work by Tome et al. [32] in 2015 applied CNNs to this problem. It includes the performance of different region proposal and feature extraction methods coupled with CNN. A different approach was observed on the thesis of Molin, D [36] where the network takes and generates the probability of pedestrian on the image pixels as the output.

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CATEGORY	METHOD	ADVANTAGES	DISADVANTAGES
Multiple camera based method using visible light and FIR cameras	Spatial-temporal filtering, seeded region growing, and min-max score fusion	• Uses data from two cameras to improve human detection accuracy	• Correspondence points must be manually set between two cameras for calibration • Requires a sequence of image frames • Difficult to use in most normal surveillance environments because of high cost of FIR cameras • Images from two cameras must be processed, which takes a long time • Processing speed is lowered if many objects are detected
Single camera-based methods(Using IR camera (NIR or FIR camera))	GMM [14], SVM classifier with feature vector from human region [15] and by HOG [16]	• Uses one camera, which eliminates the need for calibration • Faster processing time than multiple camera-based methods	• Can only be used in a fixed camera environment • If an NIR camera is used, an additional NIR illuminator must be used. • NIR illuminators are limited in terms of their illumination angle and distance, and the illuminator power must be adaptively adjusted for near and far objects • FIR cameras are expensive, and their image resolution is much lower than visible light cameras. Thus, there are few features that can be captured in a human area during human detection at a long distance [14–16]
Single camera-based methods (Using visible light camera)	Uses local change in contrast over time	Uses low-cost visible light cameras	• Can only be used in a fixed camera environment • Has trouble detecting humans who are standing still • Must use continuous video frames, which requires a fast capture speed, and it processes multiple images, which increases the processing time
Single camera-based methods (Using visible light camera)	CNN (proposed method)	Independently processes single images. Thus, even stationary objects can be detected. Can be used with moving or fixed cameras	Adequate data and time are required to train CNN

Table. 3: Comparison between different methods

The approach is quite different from the other existing methods. R-CNN [37] based pipeline was recently successfully applied to this problem. Within each class, yet still maximising class separation. Like the Eigen Face construction process, the first step of the Fisher Face technique is take each (NxM) image array and reshape into a ((N*M)x1) vector.

III. Future Trends

Even though significant progress has been made during the last decade in the field of pedestrian detection and recognition, there are a lot of challenges before the research community. Fast, simple and accurate algorithms are needed for the present detection techniques. The next steps to be performed involve training the image on a much large training set and testing the performances and also implement a hardware interface for real time applications with better accuracy and performance.

IV. Conclusion

In this paper we have introduced the various methods in pedestrian detection and major classification of various algorithms in field of segmentation and classification followed by a detailed review of some major algorithms available today. Also the accuracy of some of the algorithms and efficiency of few systems is mentioned. By taken in account to the limitations and advantages of different detection techniques, it is clear that CNN based detection including SVM and HOG classifier is the high performance high speed reduced error method. We hope that this paper will helps to know the different techniques related to pedestrian detection and also serve as a beginning knowledge to those who are new to the subject.

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