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Forecasting Of Sudden Pedesstrain Crossing For Safe Driving During Nights By High Intensity Night Vision Camera

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Abstract- **Sudden pedestrian crossing (SPC) is the major reason for pedestrian-vehicle crashes. In this paper, we focus on detecting SPCs at night for supporting an advanced driver assistance system using a far-infrared (FIR) camera mounted on the front-roof of a vehicle. Although the thermal temperature of the road is similar or higher than that of the pedestrians during summer nights, many previous researches have focused on pedestrian detection during the winter, spring, or autumn seasons. However, our research concentrates on SPC during the hot summer season because the number of collisions between pedestrians and vehicles in Korea is higher at that time than during the other seasons. For real-time processing, we first decide the optimal levels of the image scaling and search area. We then use our proposed method for detecting virtual reference lines that are associated with road segmentation without using color information, and change these lines according to the turning direction of the vehicle. Pedestrian detection is conducted using a cascade random forest with low-dimensional Haar-like features and oriented center symmetric-local binary patterns. The SPC prediction is assessed based on the likelihood and the spatiotemporal features of the pedestrians, such as their overlapping ratio with virtual reference lines, as well as the direction and magnitude of each pedestrian's movement. The proposed algorithm was successfully applied to various pedestrian dataset captured by an FIR camera, and the results show that its SPC detection performance is better than those of other methods.**

Index Terms— **Image Capture; Image Motion Analysis; Image Segmentation; Pedestrians; Video Cameras;**

I. INTRODUCTION

Digital image processing is the use of computer algorithms to perform image processing on digital images. The 2D continuous image is divided into N rows and M columns. The intersection of a row and a column is called a pixel. The image can also be a function other variables including depth, color, and time. An image given in the form of a transparency, slide, photograph or an X-ray is first digitized and stored as a matrix of binary digits in computer memory. This digitized image can then be processed and/or displayed on a high-resolution television monitor. For display, the image is stored in a rapid-access buffer memory, which refreshes the monitor at a rate of 25 frames per second to produce a visually continuous display.

II. LITERATURE SURVEY

A. *Pedestrian Detection using Visible Light Images*

The video camera technology used in capturing visible light images is mature and cost effective, and many researchers are therefore using visible light images for pedestrian detection under ideal lighting conditions. Recent studies on pedestrian detection using visible light images are as follows.

Dollár et aldemonstrated that integral channel features that are multiple registered image channels not only outperform other features, including histogram of oriented gradient (HOG), but also have few parameters and are insensitive to exact parameter settings. They showed experimentally that the proposed features allow for more accurate spatial localization during detection and result in fast detection when coupled with cascade classifiers.

Felzenszwalb et al. proposed a system for pedestrian detection based on mixtures of multiscale deformable part models and a latent support vector machine (SVM). Deformable part models are defined by a coarse root filter that approximately covers an entire object and higher resolution part filters that cover smaller parts of the object.

Vinicius and Borges proposed using the cues of a cyclic behavior in the blob trajectory and an in-phase relationship between the change in blob size and position for detecting pedestrians. To achieve performance improvement, they combined these features using the Bayes classifier.

Marin et al.'s method combined multiple local experts by means of a Random Forest ensemble based on rich block-based representations.Because the same features are reused by the multiple local experts, this method does not require additional computational cost as compared to a holistic method.

In studies that used visible light images, pedestrian detection was also analyzed in a different perspective:

Anwer et al. introduced the notion that the opponent colors (OPP) space gives a better pedestrian detection performance. They fed the OPP space into the baseline framework of Dollár et al. based on RGB color space, HOG features, and a linear SVM classifier. In they also trained and tested the part-based human classifier based on the HOG on top of OPP and demonstrated that an OPP-based method outperforms general RGB-based methods.

B. Pedestrian Detection using Infrared Camera

To resolve this limitation of visible light images, infrared (IR) camera based pedestrian detection has been receiving attention in recent years. Representative IR cameras include NIR and FIR cameras. NIR cameras are accompanied by an illuminator for nighttime use, and are less expensive than FIR cameras. NIR cameras produce images that resemble monochrome visible-light images, and thus standard image processing techniques can be easily modified for an NIR image analysis As a representative pedestrian detection system using an NIR camera.

Broggi et al. used an NIR camera on a moving vehicle for pedestrian detection. As the first step, this method enhances the bright areas in the images and surrounds them with a rectangular perimeter to reduce their size. The candidate areas are then passed to a second phase evaluation and the content of such bounding box is estimated by combining two weighted matching methods.

Ge et al. proposed a tree-structured detector using the images captured by a monocular NIR camera. This method trains separate classifiers on disjoint subsets of different sizes, and arranges the classifiers in a coarse-to-fine manner based on the Haar-like and HOG features. However, when a pedestrian is standing under or in front of a backlight, the pedestrian may be indistinguishable from the background, which is a similar case of a visible light camera. In contrast, FIR cameras, especially for long-wavelength infrared, are sensitive to the radiation emitted by the human body, and are hence very effective for pedestrian detection, especially at night [regardless of the lighting conditions and body postures. FIR cameras are relatively more expensive than video and NIR cameras. However, FIR cameras have become much cheaper, with prices reaching as low as $1,000 USD in recent years, and luxury cars have already been offering systems to increase the range of sight within the vehicle by displaying FIR images.

Many researchers have shown interest in FIR cameras for automatic pedestrian detection because they provide important human body features, such as hotspots for candidate selection.

Xu et al.proposed a pedestrian detection system based on the assumption that the human body appears brighter than the background. To search for hotspot regions, several detection phases are conducted using a SVM with size-normalized pedestrian candidates. Inspired by Xu et al.'s idea, Ko et al. also detect pedestrians by analyzing hotspot regions, including the face and shoulder areas, and verify the candidate hot spot regions using a random forest classifier. Although hotspot-based pedestrian detection provides reasonable results on the front of the face or for images taken during the winter, it produces large missing areas when the pedestrians are wearing well-insulated clothing, during a hot summer, or when the pedestrians are walking away (only the back of their head is visible).

Bertozzi et al. proposed a pedestrian detection technique that combines two FIR cameras into a single stereo system. This system exploits three different detection approaches, i.e., warm area detection, edge-based detection, and disparity computations. A candidate region is validated using the morphological and thermal characteristics of the pedestrian's head.

O'Malley et al. detect potential pedestrians using vertically biased morphological closing for compensating clothing-based distortions. The potential pedestrians are then segmented using feature-based region-growth with high intensity seeds. A SVM classifier with HOG features is used for verification.

In spite of the deterministic advantages of FIR cameras, they still have the following limitations: i) background objects, such as buildings, cars, animals, and light-poles, often have thermal energies similar to those of humans, and ii) pedestrians cannot be distinguishable from the road during a hot summer night.

III.SOFTWARE SPECIFICATION

MATLAB (matrix laboratory) is a numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPADsymbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

In 2004, MATLAB had around one million users across industry and academia. MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB is widely used in academic and research institutions as well as industrial enterprises.

B. FEATURES OF MATLAB

- High-level language for technical computing.
- Development environment for managing code, files, and data.
- Interactive tools for iterative exploration, design, and problem solving.
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, and numerical integration.
- 2-D and 3-D graphics functions for visualizing data.
- Tools for building custom graphical user interfaces.

Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, FORTRAN, Java™, COM, and Microsoft Excel.

IV. PREPROCESSING FOR CANDIDATE PEDESTRIAN DETECTION IN FIR IMAGES

A. *Determining Optimal Level of Image Scaling with Search Area*

In pedestrian detection, a multi-scale image pyramid and dense sliding windows per scale should be applied to detect pedestrians of various sizes. However, a multi-scale image pyramid is prohibitive for real-time processing. Therefore, prior knowledge regarding the size of a possible pedestrian is important. To reduce the computational cost of the image scaling, we grouped the pedestrians of our KMU dataset into six scales based on their height in pixels by changing the distance from the camera from 5 m to 30 m at 5 m intervals as shown in Fig. 2 (a). In this research, we limit the maximum distance for detecting a pedestrian at 30 m because the boundary of the pedestrian is severely blurred when located at farther than 30 m, as shown in Figs. 2 (a) and 3 (b). However, the maximum distance during the winter can be longer than in the summer because this boundary is clearer in the winter owing to the temperature contrast between the road and the pedestrian.

A detailed description of the KMU dataset is provided in Section VI. The major disadvantage of using an FIR camera, when compared with a video or NIR camera, is its low range resolution [11]. Therefore, our approach limits the maximum distance between the camera and the pedestrian to 30 m. We then select the proper size of the bounding box when using a 640 480 pixel image size for reliable SPC detection, as listed in Table I.

TABLE I
DISTANCE BETWEEN THE CAMERA AND A PEDESTRIAN AND ITS CORRESPONDING BOUNDING BOX SIZE

Distance (m)	Size of bounding box
5	196 83
10	129 54
15	90 38
20	69 29
25	62 26
30	47 20

One purpose of using different image-scaling levels according to the camera distance is to estimate the approximate distance between the vehicle and pedestrian based on the size of the detected bounding box and the position of the detected pedestrian. However, that the image-scaling level is sparse for a large bounding box but dense for a small bounding box may be one reason for the degradation in the detection accuracy of a pedestrian near the camera. To compensate for the accuracy degradation caused by different image-scaling levels within the ROI, we allow partially overlapping search areas according to the size of the bounding box, as shown in Fig. 2 (b). The search area is adjusted slightly up and down to detect a pedestrian taller and shorter than the average. The purpose of overlapping search areas is to prevent pedestrians of different heights and Fig. 2. The size of a pedestrian based on the distance for determining the image scaling level and search area: (a) the distance between the camera and the pedestrian, and its bounding box, and (b) the search area according to the scaling level.

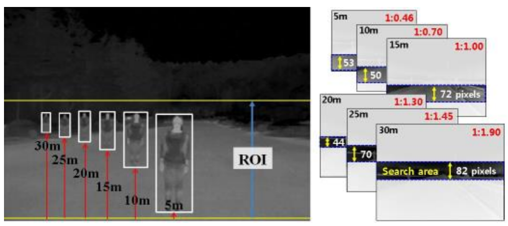

FIG 1

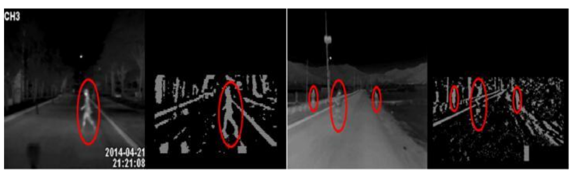

FIG 2

V. APPLICATIONS

- Image security is a major challenge in storage and transmission applications.
- Video surveillance systems for homeland security purposes are used to monitor many strategic places such as public transportation, commercial and financial centers.
  - Medical images with a patient's records may be shared among the doctors in different branches of a health service organization over networks for different clinical purposes.
  - Providing security for these images and videos becomes an important issue for individuals, business and governments as well.
  - Moreover, applications in the automobile, medical, construction and fashion industry require designs, scanned data, and blue-prints to be protected against espionage.

VI. RESULTS AND DISCUSSIONS

To evaluate the pedestrian detection performance and prove the robustness of the pedestrian detection regardless of the season, we generated training images from the KMU SP dataset as well as thermal images captured during other seasons using an FIR camera. The positive training data consisted of 4,474 thermal images including pedestrians covering a wide variety of sizes and poses. The negative data consisted of 3,405 thermal images including those randomly cropped from the background. For the testing, we collected 5,045 thermal images for pedestrian detection, including multiple (a minimum of three people) pedestrians together within an image, from the KMU SPC dataset, and thermal images captured during other season by an FIR camera. The pedestrian data included in this dataset contained multiple views: front, back, and left and right side. This dataset also can be downloaded from the same website. All experiments were conducted on an Intel Core 2 Quad processor PC with 16 GB of RAM running Windows 8.

For each test, we used the original image and six resembled images up-scaled at ratios of 1:1.9, 1:1.45, 1:1.3, and 1:1.0, and down-scaled at ratios of 1:0.7 and 1:0.46. We then applied non-maximum suppression [25] to find the best detections in each region by selecting the strongest responses within a neighborhood in an image and across scales.

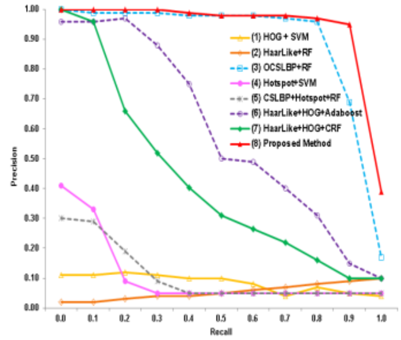

Fig. 3. Performance comparison of precision versus recall using the same KMU dataset.

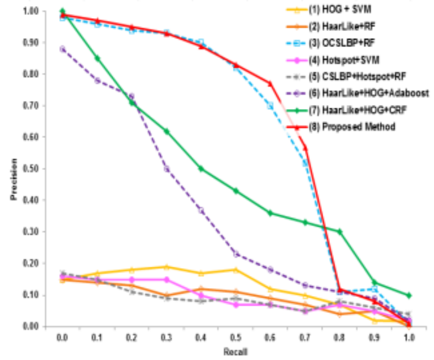

Fig. 4. Performance comparison of precision versus recall using the same CVC-09 FIR dataset.

VII. CONCLUSION

In this paper the proposed system was used the better classifiers and effective techniques to detect and track the Sudden Pedestrian crossing. For the detection of sudden pedestrian crossing we introduced the virtual reference lines concept which tracks the exact position of the pedestrian. we focus on detecting SPCs at night for supporting an advanced driver assistance system using a far-infrared (FIR) camera mounted on the front-roof of a vehicle The implemented system also added new features to detect the direction and speed of the SPC. The spatiotemporal features which considered for detecting the SPC are Overlapping ratio, Movement direction ratio and movement speed ratio. These features give the exact information of the sudden pedestrian crossing. The system‟s performance is evaluated by using the statistical measures of accuracy, specificity and computational time. By considering all the comparisons we confirm that the system works well.

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