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Vehicle Image Classification using Image Fusion at Pixel Level based on Edge Image

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***Abstract*—Vehicle class is important parameter in the process of road-traffic measurement. Currently, inductive-loop detectors (ILD) and image sensors are rarely used for vehicle classification. This paper presents the classification of vehicle image type based the coarseness and contrast of the edge image. First the edges of the image are obtained by applying first order and second order derivatives. The final edge image is obtained by performing the image fusion at different levels. The image fusion is applied to the results of classical algorithms such as sobel , Robert, LoG, canny algorithms. The final vehicle edge image is used for classification.**

***Keywords*—Edge, Coarseness, Fusion, Classification and Object Recognition**

I. INTRODUCTION

Edge detection is a vital step used for classification and recognition of objects. In a computer vision, edge detectors [1] are used to identify the object or to recognize the objects, particularly in the areas of feature detection and feature extraction, which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. Edges can be modeled according to their intensity profiles. The possible types of edges in the image content are **Step edge**: the image intensity abruptly changes from one value to one side of the discontinuity to a different value on the opposite side. **Ramp edge:** a step edge where the intensity change is not instantaneous but occur over a finite distance. **Ridge edge**: the image intensity abruptly changes value but then returns to the starting value within some short distance (generated usually by lines). **Roof edge**: a ridge edge where the intensity change is not instantaneous but occur over a finite distance (generated usually by the intersection of surfaces). Basically different methods for detecting the edges [2]-[9] uses the following four steps of edge detection.

(1) Smoothing: suppress as much noise as possible, without destroying the true edges.

(2) Enhancement: apply a filter to enhance the quality of the edges in the image (sharpening).

(3) Detection: determine which edge pixels should be discarded as noise and which should be retained (usually, thresholding provides the criterion used for detection)

(4) Localization: determine the exact location of an edge (sub-pixel resolution might be required for some applications, that is, estimate the location of an edge to better than the spacing between pixels). Edge thinning and linking are usually required in this step.

This paper is organized as follows. The proposed method is given in section 2, Results and Discussions are given in Section 3 and finally conclusion is given in section 4.

II. PROPOSED METHOD

Vehicle image classification is done based on the coarseness and contrastness of the image. Coarseness and contrast of the image can be determined based on the frequency of the edge. The following block diagram shown in Fig.1 depicts the classification of the given input vehicle image as Low-Mortar vehicle or High Mortar Vehicle. The proposed method consists of first obtain the edge images by applying first order derivates called Sobel method, Prewitt method, Canny method and Second order filter called LoG(Laplacian of Gaussian) method. In next step perform the first level image fusion on sobel edge image with prewitt edge images and Canny edge image with LoG edge image separately. Then perform second level fusion based on results obtained in the first level fusion. This final edge image is used to classify either given vehicle image as Low-Mortar vehicle or High Mortar Vehicle based on coarseness and contrastness of the edge image.

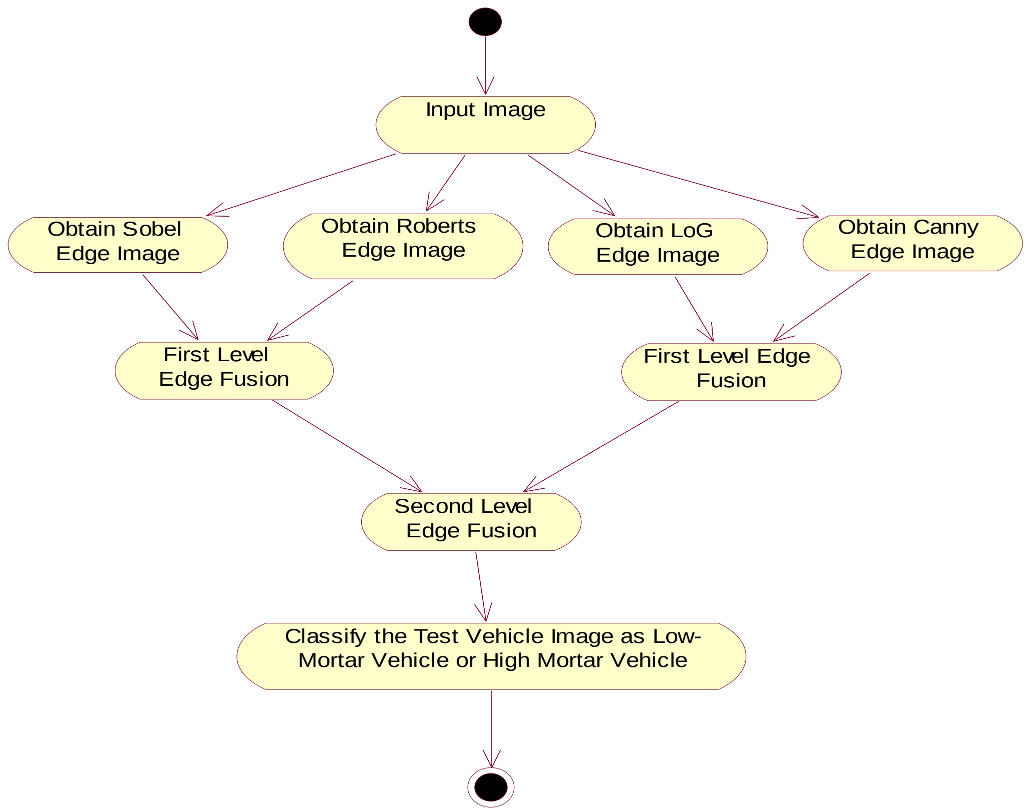

Fig 1. Block diagram for proposed method

2.1 Sobel Method - The sobel operator is used as a detector of horizontal and vertical edges, by convoluting the input image with the masks shown in fig.2 to obtain the row gradient and column gradient for each pixel.

1	2	1
0	0	0
-1	-2	-1

1	0	-1
2	0	-2
1	0	-1

Fig 2. Sobel Masks

The sobel method consists of

1.For each pixel of a image obtain row gradient by convoluting a mask of 3X 3 mask as

$G_r(f(i,j)) = (f(i-1,j-1)) + 2(f(i-1,j)) + (f(i-1,j+1)) - (f(i+1,j-1)) - 2(f(i+1,j)) - (f(i+1,j+1)$

2. For each pixel of a image obtain column gradient by convoluting a mask of 3 X 3 mask as

$G_c(f(i,j))= (-f(i-1,j-1)-2(f(i,j-1))-f(i+1,j-1)) + (f(i-1, j+1) + 2(f(i,j+1)+(f(i+1,j+1))$

3. Obtain the gradient of image pixel f(i , j) is given by magnitude of gradient

$G(f(i , j)) = Abs(G_r(f(i,j)) + Abs (G_c(f(i,j))$

4. If G (f(i , j) > T , then place that pixel in the edge image where T is an image threshold value.

5. Repeat the same procedure for all the pixels of an image to decide whether those pixels to be placed under the edge image or not.

2.2 Roberts operator edge extraction-This is the oldest operator. It is very easy to compute as it uses 2 X 2 neighborhood of current pixel. The Roberts row and column gradients are calculated by using the masks shown in fig.3.

1	0
0	-1

0	1
-1	0

Fig 3. Roberts Masks

The gradient of image pixel f (i, j) is given by using the above masks as follows.

G(f(i,j)) = Abs (1(f(i,j)) -1(f(i+1,j+1))) + Abs(1(f(i+1,j)) - 1(f(i,j+1))) is used to detect the edge pixel. If G (f(i , j) > T , then place that pixel in the edge image where T is an image threshold value.

2.3 LoG method - LoG (Laplacian of Gaussian) gradient method combines the Gaussian filtering with laplacian. The laplacian is a 2D isotropic measure of the second order derivative of an image. The laplacian gradient magnitude for image pixel f(i,j) is given in second order derivative

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

The LoG operator first uses Gaussian function to smooth the image and then calculates the laplacian gradient.To reduce the noise effect, the image is first smoothed with a low-pass filter.

Gauss function is a smooth function given by $h(r) = - e^{-r2 / 2 \sigma 2}$ Where σ is standard deviation and $r^2=x^2+y^2$. The Laplacian operator function is given by $h (r) = - [(r^2 – \sigma^2 / \sigma^4) e^{-r2 / 2 \sigma 2}]$ where h (r) is used to convolute the image. To simplify the procedure to obtain the LoG edge image convolute the image first with the Laplacian filter and then with Gaussian filter as shown in Fig.4.

0	-1	0
-1	4	-1
0	-1	0

1	1	1
1	-8	1
1	1	1

Fig 4. Laplacian and Gaussian kernels of size 3 X 3

2.4 Canny method - Canny edge detector performs the following four steps to obtain the edge images.

1.Smoothing an image with Gaussian filter.

2.Computation of Gradient.

3.Obtaining thin edges by applying non-maximal suppression

4.Detect the edges by Double thresholding.

1) Smooth image with a Gaussian – in order to remove noise in an image first smooth with Gaussian function or convolute with LoG mask. This step optimizes the trade-off between noise filtering and edge localization

2) Computation of Gradient - At each point convolve with the following masks to obtain row and column gradients as

Gr = [1 1 , -1 -1] Gc = [-1 1, -1 1] .

3) Obtaining thin edges by applying non-maximal suppression –

The obtained edge image is not clear in the above step, again apply the following non-maximal suppression algorithm in order to remove the noise existing in an image. Thin the broad ridges in M[i,j] into ridges that are only one pixel wide. Find local maxima in M[i,j] by suppressing all values along the line of the Gradient that are not peak values of the ridge by applying the following algorithm.

a) Quantize the edge directions in eight ways according to 8-connectivity
b) For each pixel with non-zero edge magnitude, inspect the two adjacent pixels indicated by the direction of its edge.
c) If the edge magnitude of either of these two exceeds the pixel under inspection then mark that for deletion.
d) When all pixels have been inspected rescan the image and erase to zero all edge data that are marked for deletion.

Even this suppressed edge image also contains many false edges due to the noise. This can be filtered by applying a concept called hysteresis to filter out the output of an edge detector as given below..

1) Check the 3 X 3 region of an each M[i,j].

2) If the value at the centre is not greater than the two values along the gradient then m[i,j] is set to zero.

3) Detect the edges by Double thresholding -Reduce number of false edges by applying a threshold T

a) All values below T are changed to 0
b) Selecting a good values for T is difficult
c) Some false edges will remain if T is too low
d) Some edges will disappear if T is too high, so apply double thresholding concept to obtain clear thin edges for an input image.

Apply two thresholds in the suppressed image

- $T_2 = 2T_1$ where T_1 is initial threshold and T_2 is doubled threshold.
- two edge images are obtained in the output by considering two thresholds T_1 and T_2.
- The edge image from T_2 contains fewer edges but has gaps in the contours.
- The edge image from T_1 has many false edges.
- Combine the results of T_1 and T_2 by using a concept, Link the edges of T_2 into contours until we reach a gap and Link the edge from T_2 with edge pixels from a T_1 contour until a T_2 edge is found again.

2.5 Image Fusion - Apply image fusion for resultant edges images obtained with Sobel method (F_1) and Robert method (F2). The sobel method identifies the diagonal edges and Robert method identifies vertical edges but the edges are thick. So the resultant edges image after image fusion more informative than these two operators that is it detects diagonal and vertical edges correctly. First level image fusion uses weighted average method to the images as shown in equation (1).

$$F(i,j)=w_1F_1(i,j)+w_2F_2(i,j) \quad (1)$$

Where w1 and w2 taken as 0.5 and

similarly perform the first level image fusion on edge images obtained by LoG method and Canny method as done in the above equation(1). The next level called second level fusion is done by using logic filtering method. It is applied to the resultant edges images from first level fusions. Here OR operator is used applied to perform the second level fusion.

2.6 Vehicle Image classification - Vehicle image classification is done based on the coarseness and contrastness of the image. The coarseness and contrast of the image can be determined based on the frequency of the edge. The coarseness means the number edge pixels in the edges image. If number edge pixels are few then the vehicle image will come under fine-grain otherwise coarse-grain vehicle. The contrastness means the sum of magnitudes of all the edge pixels in a edges image. If the sum is high enough then the image is said to be high contrast otherwise low contrast. Find out the coarseness and contrastness of the image and find out the distance of that with images that are considered under training data set in a data base by using Euclidean distance measure. Perform matching the distance calculated for the given vehicle edge image with training data set. if distance is least after comparison with training data set then classify that vehicle image as low-mortar vehicle otherwise high-mortar vehicle type.

III. Results And Discussions

The test images are classified based on the coarseness and contrastness of the image and subjective analysis on the edge images and assigned label to vehicle type is shown in figures.6 and 7.. The Fig.5 shows the sample training dataset taken for vehicle type classification.

Fig 5. Sample Training dataset

The Fig.6 shows the classifying the given test image as high-mortar vehicle and Fig.7 shows the classifying the given test image as low-mortar vehicle.

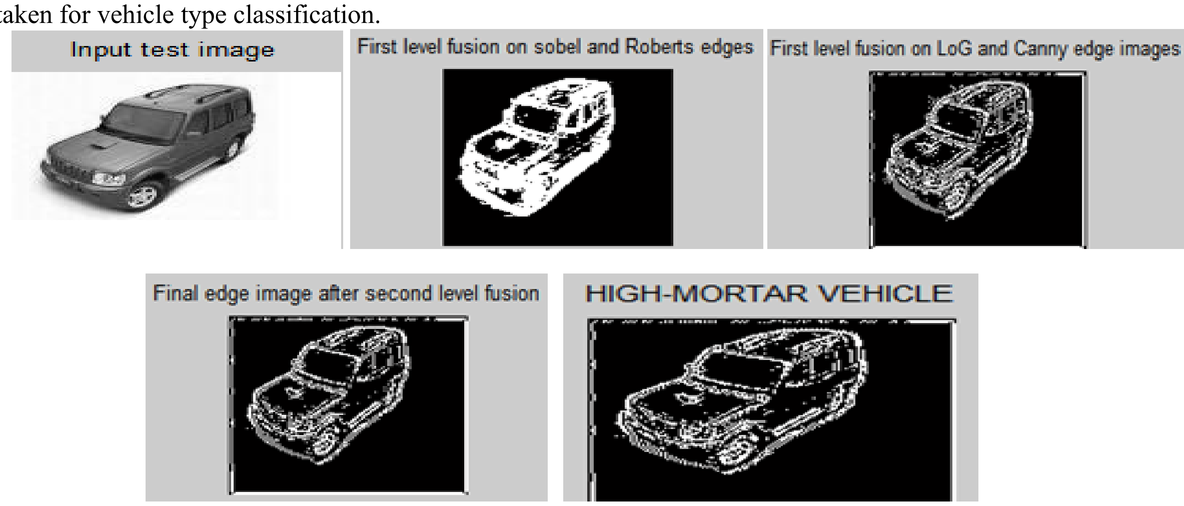

Fig 6. (a) Test image (b) Edge image after first level fusion on sobel and Roberts (C) Edge image after first level fusion on LoG and Canny methods (d) Edge image after second level fusion on outputs of first level image fusion (e) Classified vehicle type as high-mortar vehicle by proposed method.

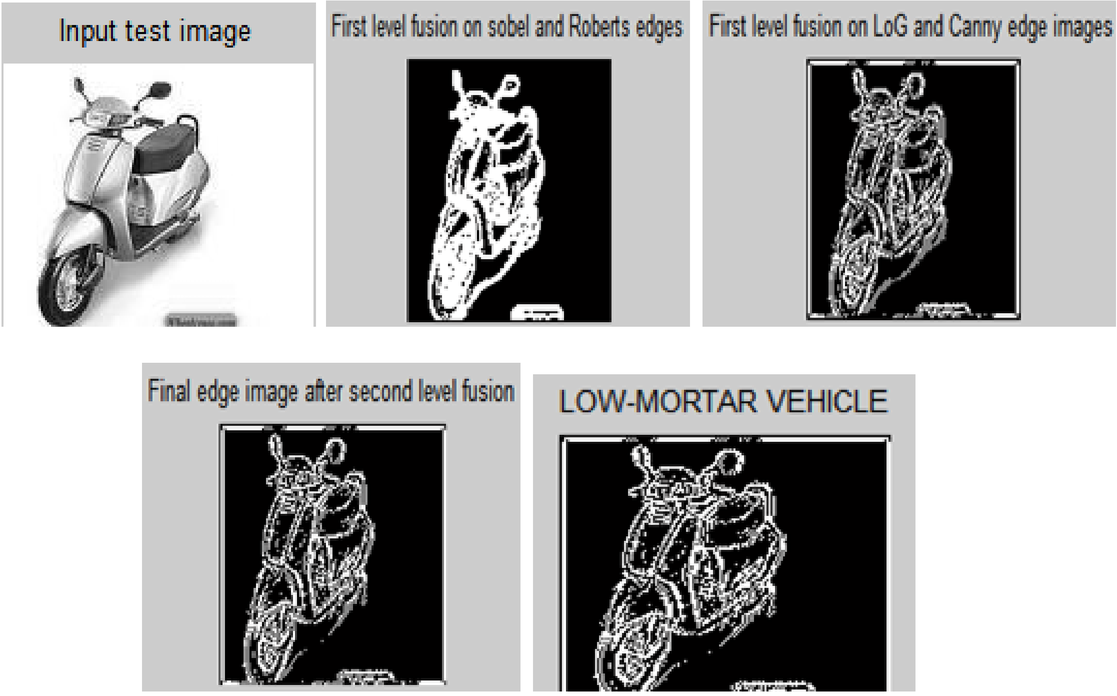

Fig 7. (a) Test image (b) Edge image after first level fusion on sobel and Roberts (C) Edge image after first level fusion on LoG and Canny methods (d) Edge image after second level fusion on outputs of first level image fusion (e) Classified vehicle type as low-mortar vehicle by proposed method.

IV. Conclusion

Image fusion can use various methods to synthesize image or image array information about a different scene and produce new explanation about that scene. The proposed method obtains clearer edge image and reflect better outline of the vehicles. The proposed method performs fusion based on simple logical filtering for all edge pixel identification. The classification is done based on the coarseness and contrastness of the image by using the distance method. Here the error rate is minimum that is it can classify the correct type of image whether it is low-mortar vehicle or high-mortar vehicle. The proposed method tested on around 500 still images and observed that given input vehicle is classified as exactly of its type.

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Biographies

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