The Classification of Gun's Type Using Image Recognition Theory

M. L. Kulthon Kasemsan

***Abstract*—The research aims to develop the Gun's Type and Models Classification (GTMC) system using image recognition theory. It is expected that this study can serve as a guide for law enforcement agencies or at least serve as the catalyst for a similar type of research. Master image storage and image recognition are the two main processes. The procedures involved original images, scaling, gray scale, canny edge detector, SUSAN corner detector, block matching template, and finally gun type's recognition. Of the 505 images, 80 were control or master images, and 425 were experimental images of the eight gun types. The finding from the experiment indicated that the GTMC was able to classify the images of the semi-automatic gun with the highest accuracy of 99.06 percent, and the average accurate gun image classification was 81.25 percent respectively.**

***Index Terms*—Canny, gun type classification, image recognition theory, SUSAN.**

I. Introduction

Literature reviews by the researchers indicated that, nowadays there are many kinds of crime and offense have been occurred by using weapons. Therefore, images from many kinds of devices such as a digital camera, a security camera, and a mobile phone are greatly significant for an investigation. These images can be used as the data analysis to arrest an offender, a trajectory, etc. A gun is a popular offensive weapon, since it can be carried, concealed, made a kill within a few seconds [1]. The researchers were expected that it will be very helpful if a computer can be played a role to classify a gun image. Moreover, literature related to a gun has been rarely emerged since the details of guns are difficult to gather, including a similar characteristic and a data access of gun. Therefore, it is necessary to concurrently study laws and characteristic of guns. The principles of law divided a gun into 2 types; (a) a private gun, and (b) a war gun. Furthermore, a gun can be classified to 8 types; revolver gun, semi-automatic gun, shotgun, sub machine gun, light machine gun, heavy machine gun, recoilless gun, and rifle gun.

At present, this study uses an image classification to extensively develop a research due to an increasing of the efficiency of a computer to process data for the image classification as humans' visibility. This will be hugely beneficial for the research. Therefore, the method of the image classification is interesting area. The images from a digital camera are clear and in high definition, so that the methods of the image classification are various. Small things such as eyelashes and blood cells are still interesting for the image classification [2]. There are existing the samples using the image classification such as a satellite, a kind of pill, and obscenity. For this research, using the image classification mixed with the image recognition, is a field of the Artificial Intelligence (AI) to enhance the efficiency for the image classification. If a computer has more memory, such object can be separated from the images as well.

Hence, this research studied the process and the image classification by using the image recognition theory. An image database preparation can be divided into 2 groups; (a) model images, and (b) experiment images. Then, all images will be processed preparation by preprocessing of scale and gray scale, to process data finding out the image detection quicker [3], [4]. Then, the image detection by Canny compared with other methods. The method of Canny will provide a high definition and utilize for small color difference [5], [6]. After getting the image detection, a line of the image detection need to be found, and examined a corner by Smallest Univalue Segment Assimilating Nucleus (SUSAN) [7]. Density of SUSAN will be used for arranging parameter. It is a basic and easier than other algorithms. Then, the line and corner will be examined similarity between a model block and a tested image. Determining a block size to be differ from a block size effects to the processing time and accuracy of the image classification [8]-[10]. A result from a block comparison will be a match point, and AVG Similarity of the image which compared with the image model will be recorded in a database. If an average of similarity shown at the image with highest value will be the Gun's Type of such model as the research's objective. The researcher hopes that the development of the image recognition system will be useful to guide the research study and other fields in the future.

II. Research Framework

TABLE I: Total Images for Test

Gun's Type	Test Images
Revolver Gun	86
Semi-Automatic Gun	107
Shotgun	51
Submachine Gun	48
Light Machine Gun	21
Heavy Machine Gun	30
Recoilless Gun	17
Rifle Gun	65
Total	425

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This study is specified only a gun image with JPG file and 2 dimensions with 250×250 pixels. A gun image which used studying has to be perfect without any damage. A gun image for testing have to be the image of a gun's side and has only one object without background. This research studied the development of learning process of a gun's image recognition with clear model and structure. Total Images for Test is as Table I.

III. Methodology

A. Process of Research

A process of research was shown as Fig. 1. It showed all processes of the image recognition system. This research will make basic processing of a gun image by scaling and gray scale quickly. Then, the image will be passed through the process of the image detection by Canny edge detector. This method will get thickness of edge detection for only one pixel. After that, the result of an image edge will be processed the line examination and find an image edge by SUSAN corner detector. A result of all image edges will be calculated compared with similarity of an image's model corner which recorded in a database. Finding the matching part of an image edge's corner by block matching and full search algorithm. A statistic value will be calculated and a kind of gun will be classified by the system. If the classification is correct, the researcher will record the model image for better recognition.

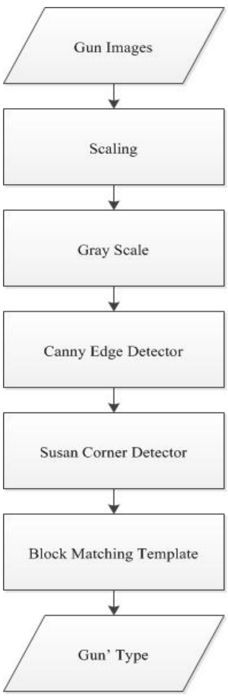

Fig. 1. A flowchart of process.

B. The Basic Image Processing

A gun image which is used in a system has to be a bitmap image with JPEG file. Data from the image file will be recorded in a computer's memory [3], [4].

1) **Scaling**: If a size of the image is too small or too large, it will effect efficiency and quality for processing. Adjusting or extending the image is necessary by making 250x250 pixels.
2) **Gray Scale**: After the image adjustment, the system will process gray scale for the edge detection. To get the result quickly, a disturb signal has to be reduced and data has to be smaller to 3:1. The color image RGB for bitmap of 24 bits consists of Red, Green and Blue (RGB). An amount of color for 8 bits will be calculated an average to get grey with the darkness range of 3 colors between 0-255.

C. Canny Edge Detector

The image of size and model adjustment to be white and grey will be processed the edge detection by Canny edge detector.

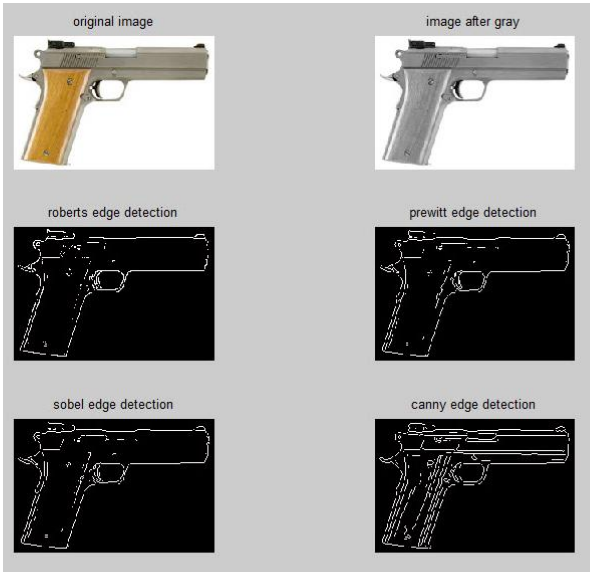

Fig. 2. The sample of the edge detection by many kinds of edge detector.

From Fig. 2, it was found that the edge detection by Canny can get details inside the object the best and utilize it in case the color difference is small compared with other methods. Since such method use the Gaussian filter before the process of the edge detection so the edge definition can be controlled and a disturb signal can be reduced. A basic image processing can be cut. With the sample of the image detection by 4 methods, the researcher can select the method of edge detection by Canny.

The working process of the edge detection by Canny has each step as following details [5], [6].

1) **Smoothing**: In the first step of image edge detection by using this algorithm, noise has to be eliminated by using gaussian filter as shown in (1).

$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}} \quad (1)$$

By σ is Standard Deviation.

Small masks are also used to calculate. If the size of gaussian mask is wider, the noise will be more eliminated. However, it should not be so wide as the details of the edges will be disappear. The image will be calculated as shown in (2).

$$S[i,j] = G[i,j,\sigma] * I[i,j] \quad (2)$$

by

$I[i, j]$ is image

$G[i, j, \sigma]$ is gaussian smoothing filter

σ is spread of the Gaussian

$S[i, j]$ is smoothing image

2) **Gradient Calculation**: Firstly, smoothing image $S[i, j]$ has to be taken to create x, y partial derivatives P[i, j] and $Q[i, j]$ respectively as shown in (3) and (4).

$$P[i, j] \approx (S[i, j+1] - S[i, j] + S[i+1, j+1] - S[i+1, j]) / 2 \quad (3)$$

$$Q[i, j] \approx (S[i, j] - S[i+1, j] + S[i, j+1] - S[i+1, j+1]) / 2 \quad (4)$$

Later, *x*, *y* partial derivatives will be used to calculated by using standard deformation formula from the rectangular to be the polar (rectangular-to-polar conversion) to identify the size and direction of gradient following to (5) and (6).

$$M[i,j] = \sqrt{P[i,j]^2 + Q[i.j]^2} \quad (5)$$

$$\theta[i,j] = \arctan(Q[i,j] / P[i,j]) \quad (6)$$

Using the above equation, the corner θ will be figured out when it is substituted by the factor in the arctan (*x*, *y*) function.

3) **Nonmaxima Suppression**: In terms of detecting the image edge by Canny method, the point that can be identified as a contour has to be the highest point and has the same direction with the gradient. This method is able to get the slim edge only 1 pixel. The image using Nonmaxima Suppression will get zero for all points except the Localmaxima points that still have the same figure.
4) **Thresholding**: Even though the image has passed the smoothing process, it is possible that the image still has inexact edges due to the noise or the surface with so many details. In order to solve this problem, the thresholds will be added covering the upper thresholding (T1) and the lower thresholding (T2). If value of the pixel is higher than T1, it will be adjusted to be 1 (the edged pixel). In contrast, pixel is lower than T2 will be adjusted to be 0. For the value between the two thresholds, the way to adjust to be 0 or 1 depends on the surrounding pixels. If the pixels around the edged pixel (value >T1) is higher than T2, value of the pixel should be 1, as same as in the edged pixel.

D. SUSAN Corner Detector

This process is taking the image from the main memory unit of the computer that have passed the initial image processing and image edge detecting to figure out the contours of the image based on the principle of SUSAN. After the positions of the contours are identified, next process is Susan corner detector in the image. This process can identify the positions of the corners with the sub pixel accuracy level and the coordinate of all points will be set up as a default to figure out the matching parts of the image block [9].

If value of difference of brightness is lower than value of threshold "t", a comparison result will be 1. If not, value will be zero. A comparison for total "N" will be an amount of a pixel in SUSAN, for example, if it is an area of SUSAN, it will be the highest value of the element's difference to figure out. Hence, the lowest value of overall parts which disturbs the image, value will be ignored.

Value of N will be compared as fixed threshold "g" which is equal to 3×N max/4. Value will be calculated from the analysis of expectation value in the part which disturbs the image.

The algorithm will get value of C as follows (7).

$$C = \exp\left(\left(\frac{d}{t}\right) \times \sigma\right) \quad (7)$$

Equation (7) will be used for the pixel having little disturbance to brightness of all values which is near value of Threshold. The figure of equation will get same value between the proper value of threshold and basic function; the pixel counting which has similar and different brightness of each pixel in the image.

A trend of a bound is related to the image which can be found for 2 ways and depends on a kind of bound point; there is a bound between a pixel and a bound in a pixel. A trend of a bound will be calculated from the longest core of SUSAN's symmetry as follows (8), (9), and (10).

$$m(X - X_O)^2 \times (R_0) = SUM\left[((X - X_O)^2 \times C\left((R, R_0)\right)\right] \quad (8)$$

$$m(Y - Y_O)^2 \times (R_0) = SUM\left[((Y - Y_O)^2 \times C\left((R, R_0)\right)\right] \quad (9)$$

$$m(X - X_O)(Y - Y_O) \times (R_0) = SUM\left[((X - X_O)(Y - Y_O) \times C\left((R, R_0)\right)\right] \quad (10)$$

by

R_0 is nucleus center

$R(R_0)$ is SUSAN center R_0

M is mean

Value of (8) and (9) will help to find the position of a bound. While (10) will identify a gradient by calculating a sum total of a part of SUSAN's value which is near a finding center. A bound of above equation is a block which identifies a bound.

E. Block Matching Template

In terms of finding the matching parts by Block Matching Algorithm will be compared the tested image block with a group of an image model. Comparing to figure out an area is called Search Area. When the matching parts are found, value will be similarity. Then, the similarity value which is higher or equal to a criterion will be selected. A result is a gun which has a similar point with the image model and recorded in a database as much as possible [6]-[8].

A comparison will use the function called Cosine function to figure out value of Mean Absolute Difference (MAD). Less value will be indicated similarity between a block as following equation (11).

$$MAD(i,j) = \frac{1}{M \times N} \sum_{m=1}^{M} \sum_{n=1}^{N} (f(m,n) - g(m+i,n+j))^2 \quad (11)$$

by $F(i,j)$ is macro block in the current frame

$G(i,j)$ is macro block in the previous frame

IV. Experimental Results

TABLE II: Indicate a Comparison of the Edge Detection's Testing Result by Roberts, Prewitt, Sobel, Canny's Method for 218 Images

Gun's Type	Test Images	Correct Images			
		Roberts	Prewitt	Sobel	Canny
Revolver gun	30	29	28	28	30
Semi-Automatic gun	30	25	27	28	27
Shotgun	30	22	21	26	27
Sub-Machine gun	30	17	14	12	16
Light Machine gun	21	15	12	16	12
Heavy Machine gun	30	21	13	16	25
Recoilless gun	17	9	11	7	11
Rifle gun	30	10	7	5	13
Total	218	148	133	138	161

Considering Table II, the researcher selected the edge detection by Canny edge detector for the system of gun image recognition. A system can exactly classify a gun image and spend time for testing less than other methods.

Considering Table III, a conclusion of testing result comparison by using a block size of 4 and 8. A result of increasing a block size for 8 was totally correct for the image classification of a kind of a shotgun. A correct result was 86.27 percent and accuracy of the image classification increased for 31.37 percent. For other kinds of guns, value of a block size rarely effects the classification.

V. Conclusion

A result of data analysis from the testing was found that: Value of a block size was equal to 4. The system can correctly classify a revolver image by 98.84 percent, a light machine gun by 71.43 percent, a heavy machine gun by 93.33 percent and a rifle by 60 percent within 2 seconds for image processing.

Value of a block size was equal to 8. The system can correctly classify a semi-automatic pistol by 99.06 percent, a revolver by 86.27 percent, a submachine gun by 64.58 percent, and a recoilless rifle by 76.47 percent within 4 seconds for image processing.

TABLE III: Compare the Testing Result of the System of Gun Image Recognition between Values of a Block Size Which is Equal to 4 and 8

Gun's Type	Block Size is Equal to 4		Block Size is Equal to 4(%)		Block Size is Equal to 8		Block Size is Equal to 8(%)	
	C*	W**	C*	W**	C*	W**	C*	W**
Revolver gun	85	1	98.84	1.16	82	4	95.35	4.65
Semi-Automatic gun	103	4	96.26	3.74	106	1	99.06	0.94
Shotgun	28	23	54.90	45.10	44	7	86.27	13.73
Sub Machine gun	24	24	50.00	50.00	31	17	64.58	35.42
Light Machine gun	15	7	71.43	28.57	13	8	61.90	38.10
Heavy Machine gun	28	2	93.33	6.77	27	3	90.00	10.00
Recoilless gun	11	6	64.70	35.30	13	4	76.47	23.53
Rifle gun	39	26	60.00	40.00	34	31	52.31	47.69
Total	332	93	78.12	21.88	350	75	82.35	17.65

C is correct*, W is wrong**

Conclusion of the processing system was correct by 81.25 percent by using only 10 model images and less time to find an answer. A result of this research was satisfactory. If the system of gun recognition has been developed, it will be more précised.

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