Low Level Algorithms in Processing Foot Print Images

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Abstract *- In person identification possibly at crime scene investigation, accident victims identification or any form of biometric verification or authentication that involves the use of foot print, divers foot prints images are acquired, stored and scrutinized by extracting features that can identify persons base on their uniqueness. Various modus operandi are needed to achieve this desire, starting from noise removal to segmentation then extraction of important features, different algorithms are involved at each of this stage. This research looks at using low level algorithms for processing foot print images for the purpose of person identification.*

Keywords*: low level algorithm, foot print images, noise removal, segmentation, feature extraction*.

1.0 INTRODUCTION

Over time image processing which is a branch of computer science is rapidly growing and extending into various fields of endeavour or profession. Image processing has become a challenging field of study in that his processes are adopted by various fields in most of their recent activities to process images for useful information gathering.For example, in medicine it is adopted for processing biomedical images, in law and crime investigation, it is adopted for processing crime scene images, in security it is adopted for processing surveillance videos and images for identification and authentication, in traffic monitoring, in business for documents analysis, in industries just to mention a few.

Image processing enhances the features of interest from an image which can be taking from various devices such as camera, video, x-ray, electron, microscopes, ultrasound etc. to extract useful information from the image by attenuating the detail irrelevant pat of the images. [8] Extracting useful information from images entails the use of computers with minimal intervention from human; it involves the usage of image processing algorithm. The algorithms which are the step by step mathematical procedures that enables task to be accomplished in order to get useful information from images. There are various stages involved in processing images to acquire needed information and for each of this stage there are various algorithms that are suitable for those tasks.

Image processing algorithms are grouped into three levels. These are low level algorithms, middle level algorithms and high level algorithms.

Low Level Algorithm

Algorithms at the lowest level are those techniques which deal directly with the raw, possibly noisy images which are digitized to pixel values. Examples are de-noising, segmentation and edge detection.

Middle Level Algorithm

Algorithms in the middle are algorithms which employ low level results forfurther means, such as segmentation and edge linking.

Highest Level Algorithm

Algorithms at the highest level are those methodswhich attempt to extract semantic meaning from the information provided by the lowerlevels, for example, handwriting recognition, face recognition, foot print recognition and so on [7].

Low level algorithms play a major role in the processing of images, as they take in images and as well gives out images as output. This level of algorithm deals with raw images enhances the images in readiness for information extraction from the images. Most images that need to be processed for facts, at the point of acquisition gather additional elements that are unwanted (noise), these in turn affects the further processes of the images and the possibility of getting accurate information from the image that is to be processed. Hence, there is need for noise removal process which is a process that is classified as a low level operation.

Furthermore, it is indispensable to enhance images that have been de-noised either by resizing, smoothening, or extracting boundaries, this process is mean to improve the clarity of the images for further processing after de-noising, as it is noted that the process of de-noising at times blurs an imageapparently removing important details with the noise. Enhancing of images too is an operation classified as a low level operation in image processing.

Foot prints are gradually gaining groundsin person identification. They may be used as evidence, identity, proves that ascertains and so on in different areas such as forensic identification: for crime scene investigation, crime suspect identifications; to exonerate or include a suspect, victims' identifications in case of accidents; where all other body part are either burnt or damaged beyond recognition, authentication, and access control; can be unobtrusively introduce to either monitor and keep record of persons that can access to a place or grant access amongst others.[1].

According to [1], divers' information can be recorded from footprint, which can be used to trace the owner of the print. Impressions from footwear can speak about the size of the shoe, the probable maker of the shoe. The barefoot print can also indicatethe likely height and weight of the owner. Also various researches show that barefoot print can equally specify the gender of the owner of print. Footprint either barefoot or footwear prints are being used for person identification nowadays especially when related to crime scene investigations.

Forensic experts adopt various techniques to study and infer information from any foot print that is to be analysed for identification. The technique to adopt is determined by the type of print at hand. Some of the techniques include the image processing technique [6].Image processing technique can be used when the footprint to be analysed can be registered as an image such as the foot print gathered from crime scene, accident victims or assassinated persons. The prints are captured as images for analysing and processing. The image processing technique involves different stages image denoising, image enhancement and features extraction also pattern recognition and pattern matching. Different algorithms are made use of at each of this stage hence the various levels of algorithm. This research looks at using the low level algorithms of image processing for processing the foot print for the purpose of person identification.

II. FOOT PRINT AS AN IMAGE FOR PROCESSING

Foot print to be analysed can be acquired using different means which include capturing as photographythrough digital camera, documentation through sketching, casting, lifting, (electrostatic lifting or adhesive lifting) [2]. Also in addition to the above listed foot print can equally be acquired through inked or inkless pad, sensing floors or mat, flatbed scanners, and so on. The next move for whatever foot print acquired is to analyse them, they are read into computer systems as images for the analysis to take place.

According to [11] and [12] as cited by [6], an image has been described as rectangular array of integers which are divided into rows and columns, with the intersection being referred to as pixel (picture element). An image is made up of several pixels;these are values which represent the intensity (brightness or darkness) of the image at a point.Also images are taken as discrete two dimensional function f(x,y) which has been quantized over its domain and range. Images are seen as a rectangular grid which consists of X rows and Y columns, whose resolution are measured by X x Y[7].

Acquiring images like the footprint image this work focuses on, from various sources introduces random changes into the values of the pixels of the image. The random changes are called noise. At the different stages involved in reading the images into the system for processing random changes are introduced, for example at capturing point using camera changes are likely introduced, at the point of transferring into system if it is from a digital camera changes are likely introduced too. If inked or inkless pad is used to acquire the prints, at the point of printing on paper, additional changes are likely introduced, while it is being scanned into the system CCD and stepper motor noise can also be added. There are different types of noise that can be introduced into an image that will cause random changes in the pixel value of the image. This work looks at using low level algorithm to remove noise from images and also prepare them for information extraction.

III. LOW LEVEL ALGORITHMS

Low level algorithms are one of the three tiers of image processing algorithms; they act directly on the raw images. These algorithms aim at extracting from the image pixel values the additional changes that were introduced to the image, also aim at get the image pixel values prepared for information extraction either by segmenting or emphasising the boundaries; edge detection. This work focuses on using low level algorithms for noise removal and segmentation of both barefoot print and footwear in readiness for further analysis that leads to person identification.

A. Noise Removal

Noise is a random variation of image Intensity and visible as grains in the image. Noise means, the pixels in the image show different intensity values instead of true pixel values. A noisy image can be modelled as follows

$$C(x,y) = A(x,y) + B(x,y)$$

where $A(x,y)$ is the original image,
$B(x,y)$ is the noise in the image and
$C(x,y)$is the resulting noise image
[10]

There are different types of noise that can affect an image. These include:

Additive noise: additive noise is independent of the pixel values in the original image [7].

Additive noise can be defined as

$$F^1(x,y) = F(x,y) + N(x,y). \quad (1)$$

where $F^1(x,y)$ is the noisy digitized version of the ideal image, F(x,y) and N(x,y) the noise function

Impulse noise this is usually as a result of an error in transmission or an atmospheric or man-made disturbance. This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise.
Multiplicative noise or speckle noise is a signal dependent form of noise whose magnitude is related to the value of the original pixel.
Gaussian noise is most common type of noise. This noise model is additive in nature and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point
Speckle or salt and pepper noise: caused by error in data transmission. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by analog-to-digital converter errors, bit errors in transmission. [10]

B. Low Level Algorithms for Noise Removal

Noise removal is a very important part of image processing, it is essential before image analysis. Acquiring accurate information from any footprint image that is meant to identify a person noise removal is an essential step that must be taken. There are ample categories of algorithms that can be used for noise removal. The best must be that which will remove noise absolutely without removing important details from the image. Filtering is a standard process that is use in almost all image processing systems for noise removal. The filtering algorithm for the noise removal can be linear or non-linear.
The Linear Filter: Linear filters are used to remove certain type of noise, linear methods are fast enough, but they do not preserve the details of the images. They tend to blur the sharp edges, destroy the lines and other fine details of image. Examples include averaging or mean filter, Gaussian filter, and Wiener filter.

The Non-linear Filter: non-linear filters have been developed to overcome the shortcoming of linear filter. These methods preserve the details of the images. Examples include median filter.

The linear filter was considered in this work, using the Gaussian filter, which has an advantage over others based on the properties of the Gaussian (e.g. the central limit theorem, minimum space bandwidth product). Gaussian filter smoothes an image by calculating weighted averages in a filter box. This is achieved by convolving the 2D Gaussian distribution function with the image. The Gaussian distribution function is expressed thus:

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

Where σ is the standard deviation of the Gaussian distribution,

σ^2 is the variance,

µ is the mean which is often zero,

x is the distance from the origin in the horizontal axis,

y is the distance from the origin in the vertical axis

(x, y) refers to a specific pixel position in the image

[3].

C. Image Segmentation

Segmentation refers to the process of partitioning a digital image into multiple segments (sets of pixels) known as super-pixels. The goal of segmentation is to simplify and or change the representation of an image into something that is more meaningful and easier to analyse, they are used to locate objects and boundaries in images. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image.[9]
Let *F* be the set of all pixels and *P*() be a uniformity (homogeneity) predicate defined on groups of connected pixels, then segmentation is a partitioning of the set *F* into a set of connected subsets or regions ($S_1, S_2, \cdots, S_n$)
such that $\bigcup_{i=1}^{n} S_i = F$ with $S_i \cap S_j = \emptyset$ when $i \neq j$.
The uniformity predicate $P(S_i)$ is true for all regions S_i and $P(S_i \cap S_j)$ is false when S_i is adjacent to S_j[5].

D. Low Level Algorithm for Image segmentation

Segmentation approaches includes Graph Methods, Clustering technique, threshold, histogram based method, edge based method, connectivity-preserving relaxation methods and region based segmentation.
Threshold techniques pixels are allocated to categories according to the range of values in which a pixel lies.
Edge based Method an edge filter is applied to the image, pixels are classified as *edge* or *non-edge* depending on the filter output, and pixels which are not separated by an edge are allocated to the same category.
Region based Segmentation algorithms operate iteratively by grouping together pixels which are neighbours and have similar values and splitting groups of pixels which are dissimilar in value.
Clustering Technique: The K-means clustering algorithm is an iterative technique that is used

to partition an image into K clusters. In this case, distance is the squared or absolute difference between a pixel and a cluster center. The difference is typically based on pixel colour, intensity, texture, and location, or a weighted combination of these factors.
[9] [5].
All various segmentation methods listed above rely on algorithms for the processes to be carried out. Some of the relevant algorithms include for *Edge detection method*, Sobel edge method, Canny edge method, Prewitt edge method, Zero cross method. For *Clustering Method*, k-means clustering, Fuzzy mean clustering. Other algorithms that can be used include the Neural network, watershed algorithms, seed growing algorithm, and lots more[9].
This research looks at K-means clustering as a low level algorithm for segmenting the foot print images for segmentation

IV. METHODOLOGY

Footprints were gathered from volunteers, by requesting that they step on ink pad and print this on cardboard by stepping on cardboards with just their right legs three times. Some of this prints made on the cardboard were smudged because of ink quantity, especially the first print each individual made. These made prints were then scanned into the system for processing. At the point of scanning the prints, additional noise were introduced to the images that were kept in a folder for further processing. Hence, the need for removing noise from the images for clarity of processing.

Representing an image of footprint as $I(x,y)$ but with noise say $N(x,y)$, the noisy image become $I^1(x,y)$

$$I^1(x,y) = I(x,y) + N(x,y) \quad (3)$$

Where N(x,y) is the added noise
I(x,y) is the ideal footprint image that has to be reclaimed
$I^1(x,y)$ is the noisy image from footprint

So $I^1(x,y)$ convolve with Gaussian filter gave a blur image where the noise ($N(x,y)$) has been removed

$$F(x,y) = I^1(x,y) \ * \ G(x,y) \quad (4)$$

Where $G(x,y) = \frac{1}{2\pi\sigma} e^{-(\frac{x^2+y^2}{2\sigma^2})}$ the Gaussian function for removing the noise

and F(x, y) is the filtered vectored image.

The filtered image F(x,y) is then segmented using the K-means clustering techniques

Given the filtered vectored image $F(x, y)$

Such that $F(x, y) = x_1y_1, x_2y_2, x_3y_3, \ldots, x_ny_n$

$$(5)$$

Where n is the size of vectored image

$F(x,y)$ is partitioned into k sets/groups S

$$S = S_1, S_2, \ldots, S_k \quad (6)$$

Where $K \leq n$

The mean (μ) for each cluster group S, is computed and the distance between μ and each x_i, y_j is minimised to obtained the cluster group for x_i, y_j .

The squared Euclidean distance from each pixel to each cluster is calculated and each pixel is assigned to the closest cluster.

Assigning a mean for a particular cluster to a pixel is computed as:

$$d(F(x_i\ y_j), \mu_l) = (F(x_i\ y_j) \ - \mu_l \ )^2 \quad (7)$$

To assign each pixel closest cluster is computed as:

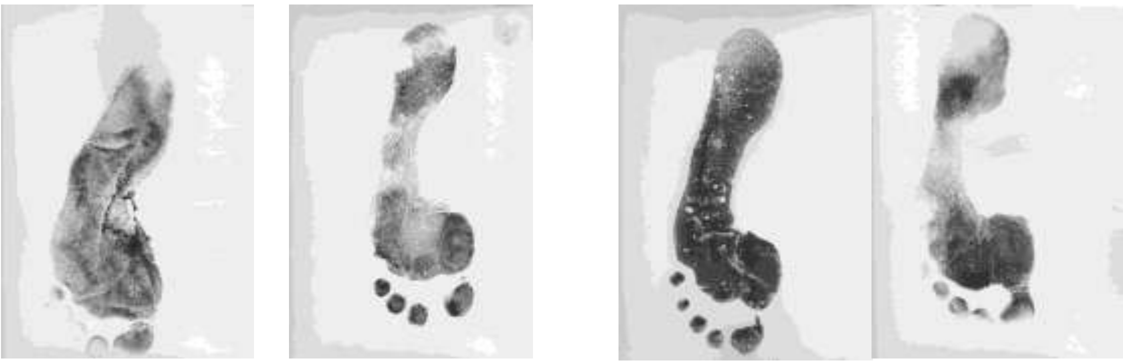
$$d(F(x,y), \mu) = \beta[\cup_{i,j}^{n} x_i\ y_j] \overset{m}{\leftarrow} \{\cup_l^k \mu_l\} \quad (8)$$

Where x_i, y_j represents the pixel from the vector image $F(x, y)$,
β is a function that assigns($\overset{m}{\leftarrow}$) the pixel to the closest cluster,
μ_l represents the mean for eachcluster and $d(F(x,y),\mu)$ is a cluster vector image.
i *and* $j = 1,2,3,\ldots,n$, and $l = 1,2,3,\ldots,k$

V.RESULTS DISCUSSION

A. *Noise Removal*

Some sample noisy image that were acquired are shown in figure 1,there are about four different footprints shown



(a) (b) (c) (d)

Figure 1, images a – d of four different acquired noisy footprints

The image denoising was achieved by supplying the Gaussian radius and sigma value which was used to determine the level of enhancing the images. The *Sigma* value is the important argument, and determines the actual amount of blurring that will take place. The *Radius* is only used to determine the size of the array which will hold the calculated Gaussian distribution. It should be an integer. The larger the *Radius* the slower the operation is. However too small a *Radius*, and sever aliasing effects may result. As a guideline, *Radius* should be at least twice the *Sigma* value, though three times will produce a more accurate result

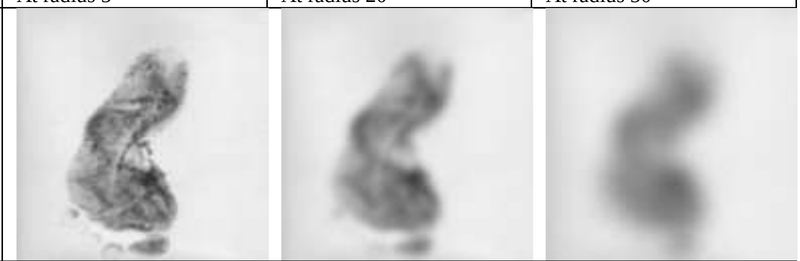
Label	At radius 5	At radius 20	At radius 50
A			
b			
C			
d			

Figure 2 the de-noised images at different radius values 5, 20 and 50

B. *Segmentation*

These images were further segmented into clusters using K-means algorithm by specifying the cluster count. Different cluster counts were specified in order to pick the appropriate cluster count for the prints, it is observed that the higher the cluster count the incompetence the clustering becomes. For the prints filtered at radius 20 the segmentation was done using two different counts, these are shown in figure 3.

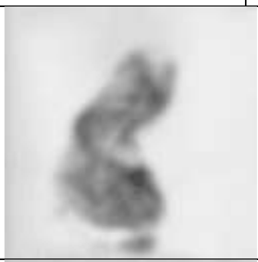
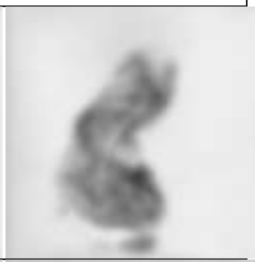
Label	At Cluster count 50	At Cluster count 150
A		
b.		
c.		
D		

Figure 3 Segmentation using K-means clustering with cluster counts 50 and 150

V. CONCLUSION

This paper focused on processing footprint images for person identification by adopting low level algorithms; noise removal and segmentation. Algorithms which were implemented with java codes generated at both stages. The accuracy of noise removal with the Gaussian filter was determined based on the specified radius, the larger the *Radius* the slower the operation is and the higher the possibility of removing important information on the image. The lower the radius the faster the operation and the higher the possibility of having noise left. As a guideline, *Radius* should be at least twice the *Sigma* value, though three times will produce a more accurate result. The accuracy of the K-means cluster was determined when all pixels in the image had been successfully grouped into clusters and SSE the sum of squared within group errors cannot be lowered to any further extent. The resulting output can be used to identify a footprint found at any location say crime scene or used to identify a body say accident victims provided there has been a database kept of various footprints.

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