Automatic surface Defect identification in tanning industry using Pixel Connectivity based Edge detection algorithm

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Abstract

Leather is a durable and flexible material created by the tanning of animal raw hide and skin. It is an intermediate industrial product, with numerous applications in the consumer products industry. Leather defects are imperfections occurring in the grain surface or structure of the hide or skin, in the form of scars, abrasions etc., when neglected leads to bring down the quality and reliability of the product. The process of defects identification is carried out at the output of the tanning industry. Visual inspection of leather surface defects is very important in the manufacturing of leather products that require unusually high quality. These operations are currently performed by human inspectors who tend to miss considerable numbers of defects. Automated inspection and classification can reduce human workloads and labour costs while increasing throughput. More importantly, higher accuracy can be achieved by eliminating human error due to fatigue. This paper proposes an accurate and computational efficient pixel connectivity based edge detection algorithm that automatically identifies leather surface defects.

Keywords: *Leather defects, addere and divisio, sobel, canny, LOG, prewitt, Roberts.*

1. Introduction:

Leather is an intermediate industrial product, with numerous applications in the Consumer products industry. It is often the major material input, and is cut and assembled into Shoes, clothing, leather goods, furniture and many other items of daily use. Different applications require different types of leather. The tannery operation involves converting the raw skin, a highly putrescible material, into leather, a stable material, which can be used in the manufacture of a wide range of products. The whole process involves a sequence of complex chemical reactions and mechanical processes.The leather manufacturing process is divided into three sub-processes: preparatory stages, tanning and crusting. Tanning is the process that converts the protein of the raw hide or skin into a stable material which will not putrefy and is suitable for a wide variety of end applications. The principal difference between raw hides and tanned hides is that raw hides dry out to form a hard inflexible material that can putrefy when re-wetted (*wetted back*), while tanned material dries out to a flexible form that does not become putrid when wetted back. The process of defect identification is carried out at the output of the tanning industry. Segregation of the defective and the non-defective leather should occur before the tanned leather product is used to manufacture the finished goods. The effect of damage caused to the hide of an animal during its lifetime is a major problem to the tanning industry. Such damage may result in defects existing in the processed leather hide, in the form of scars, abrasions and others. The nature and quality of defects existing in any particular hide will effect its application in the manufacture of leather goods. Areas of hide containing defects may be considered unusable or useful only for particular purposes. Hence, it is important that, before the manufacture of final leather goods, it is necessary to inspect a hide to determine the location of non-defective areas which can be used in manufacture. The defect areas may either be removed or may be processed separately for some other relevant applications.

These operations are currently performed by human inspectors who tend to miss considerable numbers of defects. Furthermore, since manual inspection and classification are slow and labour-intensive tasks, they can become a critical bottleneck in the entire production process. Automated inspection and classification can reduce human workloads and labour costs while increasing throughput. More importantly, higher accuracy can be achieved by eliminating human error due to fatigue. To automate the process the leather sample has to be converted in to digital image and processed with efficient image processing algorithms to identify the defective area. The basic processing techniques involve pre-processing, image segmentation and defect identification. Pre-processing is the method used to filter the image from noise, introduced during capture of leather image. As the defective area is a rough surface which has some isolated pixel properties like brightness, pixel strength compared to neighbour pixels, In this paper edge detection is choose as a segmentation method for identifying defect, But due to the complexity involved in leather surface identifying the defective area using only conventional edge detection algorithms doesn't shows to be a best solution. Hence the edge detected image is future processed to remove the unwanted edge pixels which are out of defective area based on their pixel connectivity.

To made the algorithm computationally efficient and accurate we choose the edge detection method adder and division [4], this method takes almost the time needed for sobel to operate and less computation compared to sobel edge detection algorithm with efficient output (2).

2. Edge detection methods:

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges.

2.1 Sobel edge detector

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°.The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G*x* and G*y*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

Gradient magnitude: |G|= sqrt (Gx^2+Gy^2).

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by: arctan (G*x*/G*y*) [6].

Gx

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

Gy

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

Figure 1 Masks used by sobel

2.2 Roberts edge detector

The operator consists of a pair of 2×2 convolution kernels as shown in Figure 2. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator [6].The gradient magnitude: |G|= sqrt (Gx^2+Gy^2) .The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by: arctan (Gx/Gy **-** (3π/4)).

Gx

+1	0
0	-1

Gy

0	+1
-1	0

Figure 2 Masks used by Roberts

2.3 Prewitts edge detector

Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images.

(a) Gx

-1	0	+1
-1	0	+1
-1	0	+1

(a) Gy

+1	+1	+1
0	0	0
-1	-1	-1

(b) Gx

1	1	1
1	-8	1
1	1	1

(b) Gy

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

Figure 1 (a) Masks used by Prewitts (b) LOG

2.4 Laplacian of Gaussian

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection.The Laplacian *L(x,y)* of an image with pixel intensity values *I(x,y)* is given by: $L(x,y)=(d^2I/dx)^2+ (d^2I/dy)^2$. Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian. Some commonly used small kernels are shown in figure.3(b).Because these kernels are approximating a second derivative measurement on the image, they are very sensitive to noise. To counter this, the image is often Gaussian Smoothed before applying the Laplacian filter. This pre-processing step reduces the high frequency noise components prior to the differentiation step [6].

2.5 Addere and Divisio algorithm:

Step 1: The pixels in the image are scanned row by row from top left to bottom right and the pixel values are stored in a one dimensional array called Image- pixel array.

Step 2: Starting from the first element of the array, two consecutive pixel values from the Image- pixel array are taken at a time and added together and divided by 2. The resulting values are stored successively in another one dimensional array called Averages array.

Step 3: Similarly, starting from the first element, two consecutive values from the Averages array are taken at a time and added together and divided by 8. The resulting values are successively stored in a third array called One- eight array.

Step 4: In a similar manner, starting from the first element of the One-eight array, two consecutive pixels are taken at a time from the One-eight array and added together and the results are successively placed in another array called Final-array.

Step 5: The highest value of the Final- array is taken and divided by the value 3. This value acts as the threshold value. The value 3 has been obtained by extensive experimentation.

Step 6: The original image pixels are retrieved row wise starting from top left and two consecutive pixels are taken at a time and if the absolute value of the difference of the two is greater than the threshold, then, the former pixel value is set to 1, otherwise, it is set to 0. This process goes on row wise from top left to bottom right end, till the end of image is reached, and the pixel values are set accordingly. Furthermore canny edge detector principle of operation ,Entropic threshold based edge detector [3][4] and comparison among all the above edge detectors are computed (4).

3. Automatic Defect identification on leather image:

3.1 Proposed algorithm:

Step 1:

$$\sum_{i1=1}^{m-1}\sum_{j1=1}^{n1-1}\left[\left(xfth(i1,j1)=\left(\frac{xavg(i1,j1)+xavg(i1,j1+1)}{fth}\right)\left(\sum_{i=1}^{m}\sum_{j=1}^{n-1}\left(xavg(i,j)=\frac{x(i,j)+x(i,j+1)}{2}\right)\right)\right)\right]$$

Where x (i,j) is intensity of original image at i,j pixels , *fth* is the fixed threshold value throughout the process. We took it as value 8 decided from multiple experimentation.

Step 2:

$$\sum_{i2=1}^{m}\sum_{j2=1}^{n-1}\left(xfthsum(i2,j2)=xfth(i2,j2)+xfth(i2,j2+1)\right)$$

$$\text{TH}=\frac{\max(xfthsum)}{ranth}$$

Where *ranth* is the random value based on the type of input complex image. Here we took it as 3 which decided from multiple experiments.TH is the obtained threshold value which decides the Original pixel value is either edge or not.

$$\sum_{i=1}^{m}\sum_{j=1}^{n-1}\{\,h(i,j)=abs[x(i,j)-x(i,j+1)]\,\}$$

If h (i,j) ≥ TH then x(i,j) = 1

Else x (i,j) = 0

Now *x (i,j)* is the edge detected image of original image. Whose output contains edges of image due to damage area and edges due to the complex natured surface of leather observed as some isolated white pixels on image.

Step 3:

If

$$\left(\sum_{i}^{m-3}\sum_{j}^{n-3}\left(\begin{matrix}xs'(i,j)+xs'(i,j+1)+xs'(i,j+2)\\+xs'(i+1,j)+xs'(i+1,j+1)\\+xs'(i+1,j+2)+xs'(i+2,j)\\+xs'(i+2,j+1)+xs'(i+2,j+2)\end{matrix}\right)\right)\leq ¢$$

Then

$$\left(\sum_{i}^{m-3}\sum_{j}^{n-3}\begin{matrix}x(i,j)=x(i,j+1)=x(i,j+2)\\=x(i+1,j)=x(i+1,j+1)\\=x(i+1,j+2)=x(i+2,j)\\=x(i+2,j+1)=x(i+2,j+2)\end{matrix}\right)=0$$

Where ¢ is the threshold value taken 3 which decides the group of pixels chosen are isolated Edge pixels are having some relation with neighbor edge pixels. Here *xs'(i,j)* is same as of edge image finally freed from isolated edges[5].

Step 4: To identify and detect the damage area on leather surface we took four isolated edge pixels from step3 image. The pixels are selected with the criteria that those are the best pixel locations which occupy entire damaged area. Pixels are selected from top, bottom, left, right directions of the image.

Step 5: these four pixels take on four directions are then used to isolate the defective area on the leather surface.

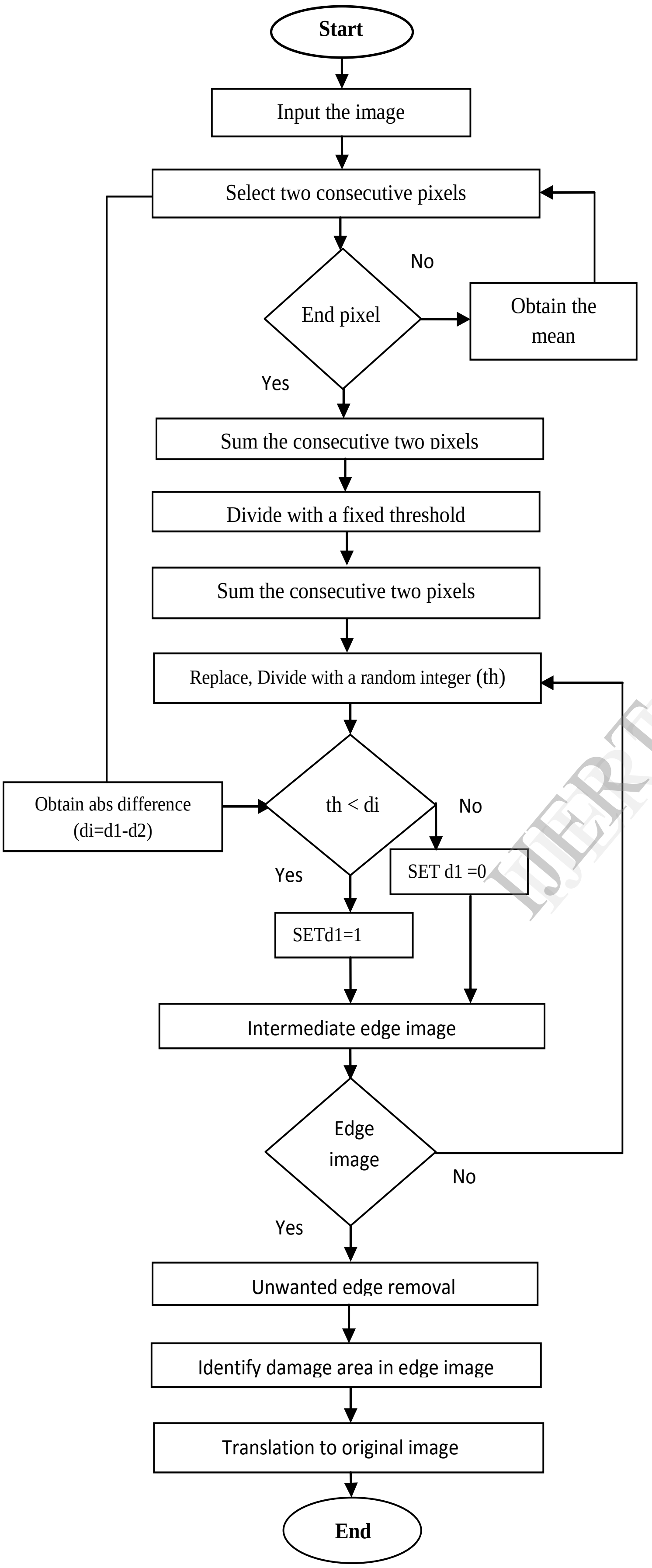

Figure 5 Automated defect detection on leather surface

4. Result :

Table 1 : Execution time for 256×256 image

Sino	Type Of Edge Detector	Execution time (sec)
1	Sobel	0.41
2	Log	0.05
3	Canny	0.33
4	Prewitt	0.35
5	Roberts	0.35
6	Zero cross	0.25
7	Proposed	0.31
8	Fuzzy logic (2,2)	23.02
9	Entropic threshold	0.05

Table 2 : Execution time for 3K×3K image

Sino	Type Of Edge Detector	Execution time (sec)
1	Sobel	54.53
2	Log	9.44
3	Canny	18.01
4	Prewitt	55.13
5	Roberts	55.37
6	Zero cross	9.47
7	Proposed	54.18
8	Fuzzy logic (2,2)	2456.09
9	Entropic threshold	3.84

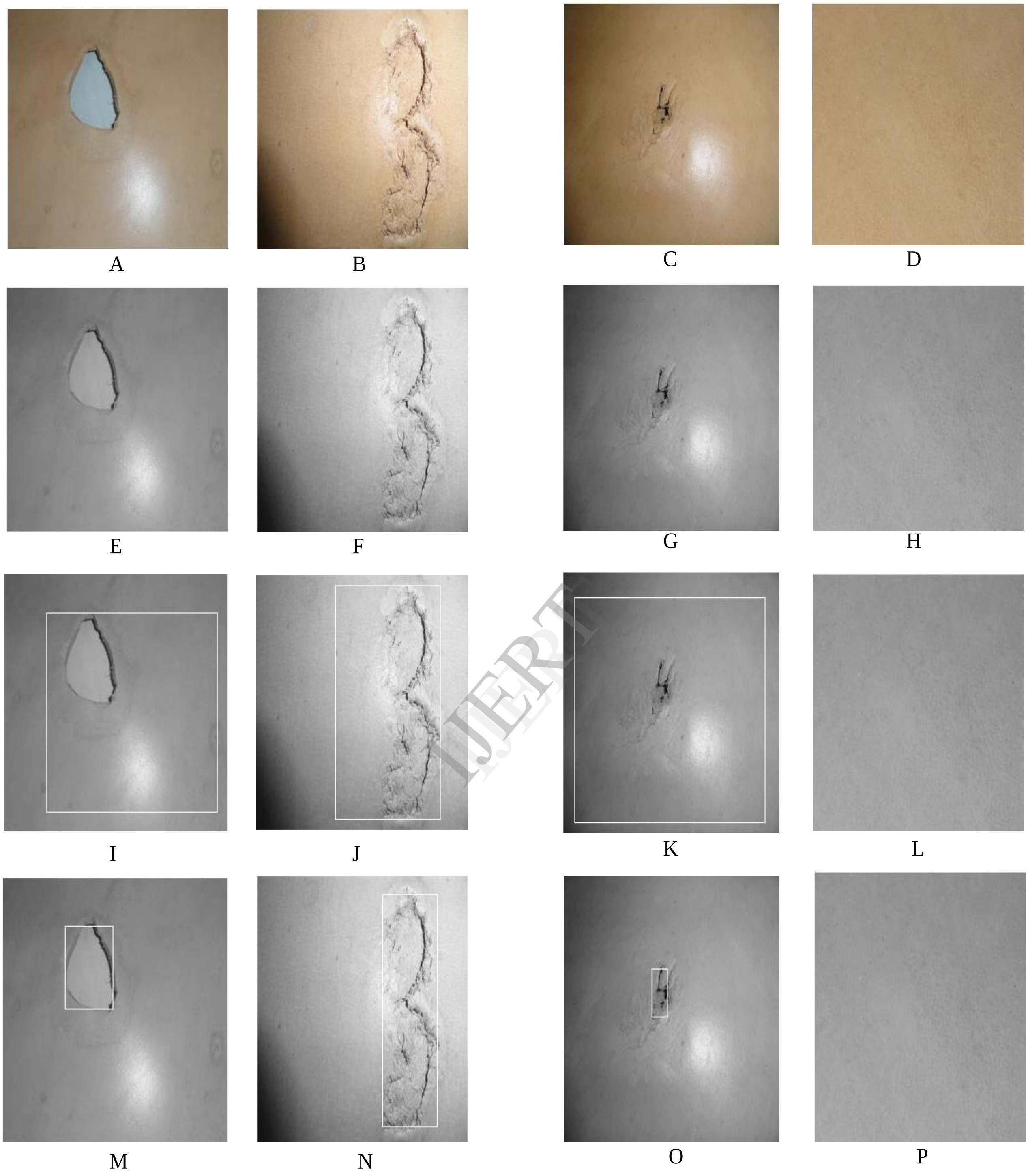

Figure 4 A) sample 1 B) sample 2 C) sample 3 D) sample 4 E) Gray sample 1 F) Gray sample 2 G) Gray sample 3 H) Gray sample 4 I) Detected by sobel for sample 1 J) Detected by sobel for sample 2 K) Detected by sobel for sample 3 L) Detected by sobel for sample 4 M) Detected by proposed algorithm for sample 1 N) Detected by proposed algorithm for sample 2 O) Detected by proposed algorithm for sample 3 P) Detected by proposed algorithm for sample 4

It is observed from Table 1 and Table 2 that execution time for entropic threshold algorithm is very less and Fuzzy logic (2, 2) is more on images of size 256 ×256 and 3K ×3K, where as the proposed algorithm has execution time as that of sobel edge detector. By implementing both the edge detector algorithms on the four leather samples, from figure 4 we had the accurate defective area identified with the proposed algorithm. The identified defective area is shown with a white rectangular box in the figure.

Future Scope: In this paper we have taken leather samples of same pattern, with minimum enhancement in the algorithm it can directly implement to identify surface defects on any pattern of leather.

6. References:

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