Detection of Impurity in Liquids Using Electronic Sensor Based System with Infrared Camera

Smita A. Nagtode[1]
Department of Electronics & Telecommunication
D.M.I.E.T.R., Sawangi (Meghe), Wardha
Wardha, India
Smita_nagtode@rediffmail.com

N.K. Choudhari[2]
Department of Electronics Engineering
Smt. Bhagwati Chaturvedi College of Engg, Nagpur
Nagpur, India
drnitinchoudhari@gmail.com

***Abstract*— This paper is based on new enhancement technique for infrared images which integrates the benefits of additive wavelet transformation and homomorphic image processing. The main motive behind this technique is to decompose the images into subbands in an additive fashion and the principle adopted to implement the same is using additive wavelet transform which produces the image as an addition of subbands of the same resolution.**
Each subbands is subjected to homomorphic processing and it is learned that when images are subjected to homomorphic processing in the log domain , the images are transformed into illumination and reflectance components. When the reflectance components are enhanced it reinforces the details in the image so here this process is applied to each subband to enhance the details of image in each subband. In the final step these homomorphic enhanced subbands are subjected to an inverse additive wavelet transform to get an infrared image with better visual details. The results obtained using this algorithm reveal its ability to enhance the infrared images.

Keywords*— Wavelet transform, Homomorphic processing, illumination component, reflectance component, subband.

I. INTRODUCTION

Biomedical Devices have more and more important in modern life where population is aging. Electronic Tongue and Electronic nose [1-8] system provides more services in various fields such as environmental monitoring, food science, and point of care business. The concept of electronic tongues is more recent, and much less research has been undertaken on the development of liquid sensors and classification algorithms.

By combining sensor systems e.g. Electronic noses and tongues together with a enhanced image processing techniques, the classification accuracy can be increased. In the proposed research work, it is planned to develop an electronic system that can be used for analysing liquids like milk, oil, water, juices, etc. The system hardware and software will be designed and developed and efforts will be taken to analyse liquid. Research work involves use of Image processing techniques, developments of new algorithms, continuous monitoring of the liquids under test, and evaluation of properties of liquid and hence quality of liquid.

The following will be the steps under taken for the research work,

- Detailed study of the concept, application and implementation of sensor networks.
- To design and develop an electronic sensor based system that can extract the information about the properties of the liquid.
- Identify and analyse the effect using sensor based system, due to the liquid or any other ingredients present in liquid.
- PC interface will be developed for online testing and monitoring.

Evaluation results will be made available on display, displaying the quality of liquid under test.

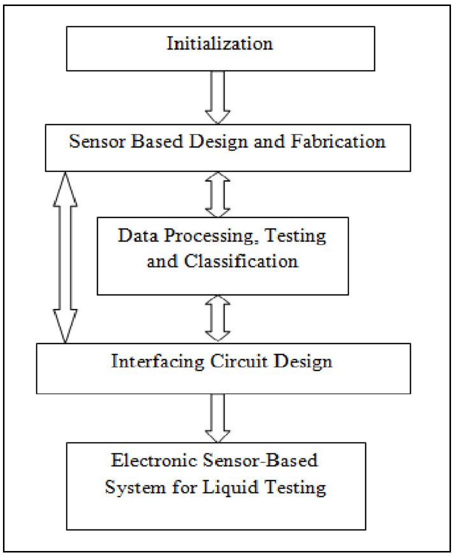

Figure 1: System representation.

Image enhancement has became a very popular field in image processing . The main aim of Enhancement is to improve the visual quality of image and this is achieved by reinforcing edges and smoothing the flat areas. Several researches have adopted various techniques in past such as simple filtering , adaptive filtering , wavelet de-noising , homomorphic enhancement etc.,[8-15] and all these techniques concentrate on reinforcing the details of the images to be enhanced.

Apart from all these techniques mentioned above , a new technique that is Infrared image processing has emerged for the evolution of night vision cameras.

This technique has various advantages such as this technique has applications in thermal medical imaging[8-10,12]. With the evolution of night vision cameras , more researches are being performed in infrared image enhancement for information extraction from these images. Due to the absence of appropriate amount of light required for imaging , these images have a special nature of large black areas and small details . Hence , the main objective is to reinforce the details to get as much details as possible.
The enhancement of infrared images is slightly different from traditional image enhancement because this infrared image have large black areas and small details. So, our proposed methodology aims at separating the details in different subbands and processing each subband separately.
It is found that additive wavelet transform is a very powerful tool in image decomposition and the details can be separated into the higher frequency subbands , if the images is decomposed using the additive wavelet transform.
In addition to all these we also use the homomorphic enhancement algorithm for transforming these details to illumination and reflectance components and then the reflectance components are amplified showing the details clearly. In the final step , to get an enhanced infrared image with much more detail , a wavelet reconstruction process is performed.

II. Additive Wavelet Transform

The main role of additive transform [16,19] is that it decomposes an image into the subbands using the "a' trous" filtering approach in several consecutive stages. The low pass filter is used in this process and has the following mask for all stages:

$$H = 1/256 \begin{pmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{pmatrix} \quad \ldots\ldots \quad (1)$$

Each difference between filter outputs of two consecutive stages is a subband of the original image. We can use these subbands for further processing using homomorphic enhancement.

III. HOMOMORPHIC IMAGE ENHANCEMENT

An Image can be represented by the following equation which is a product of a tow component :

$$f(n1, n2) = i(n1, n2)\, r(n1, n2) \quad \ldots\ldots. \quad (2)$$

where the obtained image pixel is given by f(n1, n2) and i(n1, n2) is the light illumination incident on the object to be imaged and r(n1, n2) is the reflectance of that object.

It is known that light falling on all objects is approximately the same therefore due to this the illumination is approximately constant and the only change between the object images is in the reflectance component.
The above mentioned equation 2 can be changed to addition process from multiplication process by applying logarithmic process to equation 2 and the new equation form by applying the same is as follows:

$$\log(f(n1, n2)) = \log(i((n1, n2)) + \log(r(n1, n2)) \ldots \quad (3)$$

As shown in the above equation the first term has smaller variations but the second term has large variations as it corresponds to the reflectivity of the object to be imaged.
We can reinforce the image details by attenuating the first term and reinforcing the second term in equation (3).

IV. PROPOSED APPROACH

In this approach , firstly the image is decomposed into subbands using the additive wavelet transform and then each subband is processed separately using the homomorphic approach to reinforce its details and by this way we merge the benefits of the above mentioned techniques. In the experimental setup we connect twenty infrared Light emitting diode (IR LED's) across camera and when this IR LED's is ON human eye cannot detect this but it can be easily captured by Camera.
The steps of the proposed approach can be summarized as follows:

1. In the first step Using additive wavelet transform and the low pass mask of equation (1) , the infrared image is decomposed into four subbands p3, w1, w2, w3.
2. In the second step, a logarithmic operation in each subband is applied to get the illumination and reflectance component of the subbands w1, w2 and w3 as they contain the details.
3. In the third step attenuation operation is performed on illumination component and reinforcement operation is performed on reflectance component in each subband.
4. Using addition and exponentiation processes each subband is reconstructed from its illumination and reflectance.
5. Perform an inverse additive wavelet transform on the obtained subbands by adding p3, w1, w2 and w3 after the homomorphic processing to get the enhanced image.

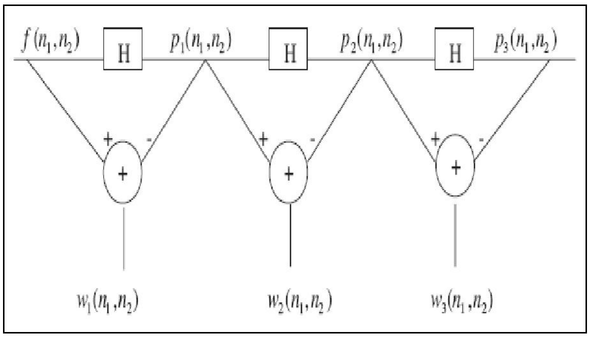

Figure 2: Additive wavelet decomposition.

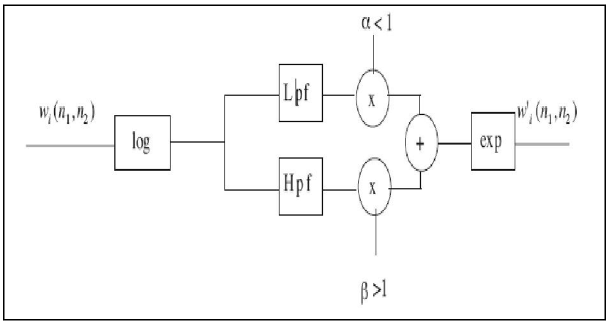

Figure 3: Homomorphic processing of subbands, i=1, 2, 3.

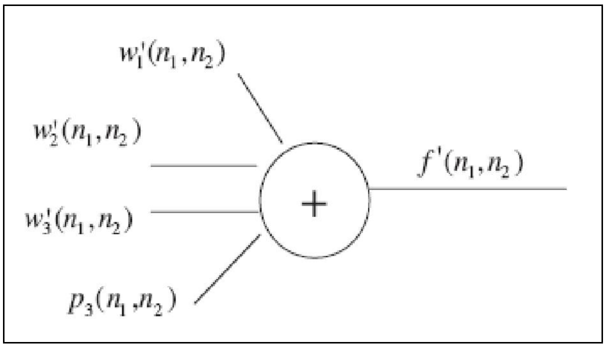

Figure 4: Wavelet Reconstruction.

V. EXPERIMENTAL RESULTS

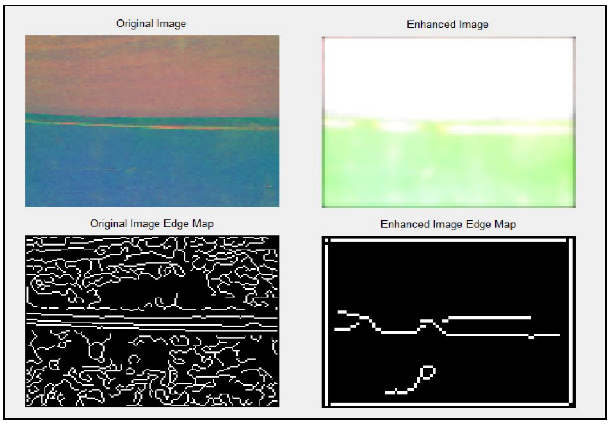

Figure 5: Results of first experiment (Liquid-Water)

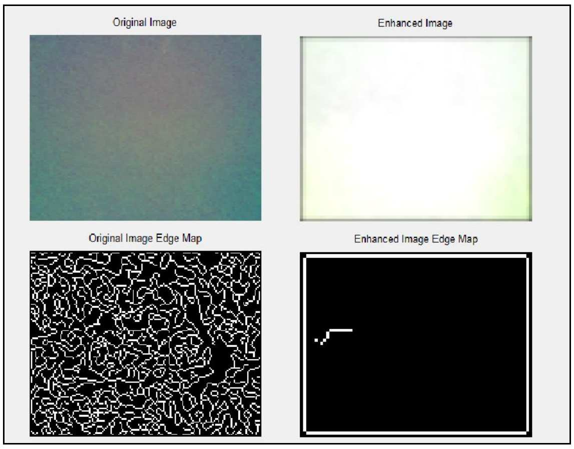

Figure 6: Results of second experiment (Liquid – Water with small impurity)

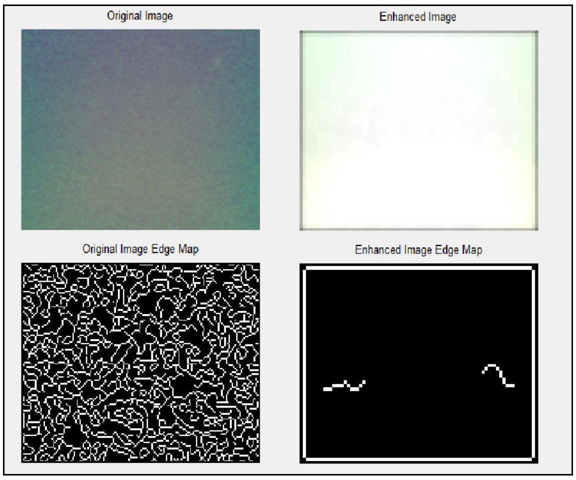

Figure 7: Results of third experiment (Liquid- Water with impurity)

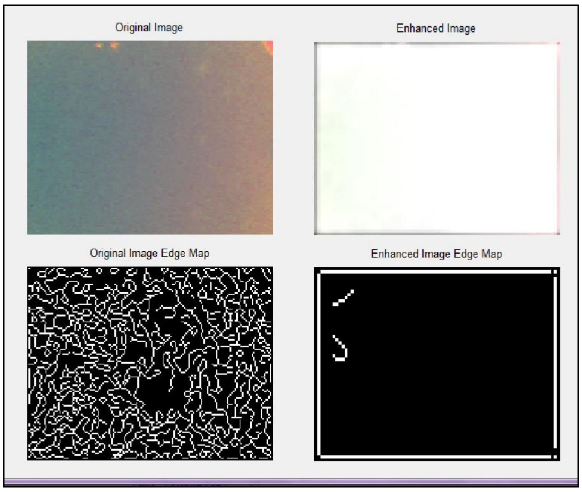

Figure 8: Results of fourth experiment (Liquid- Pure Milk)

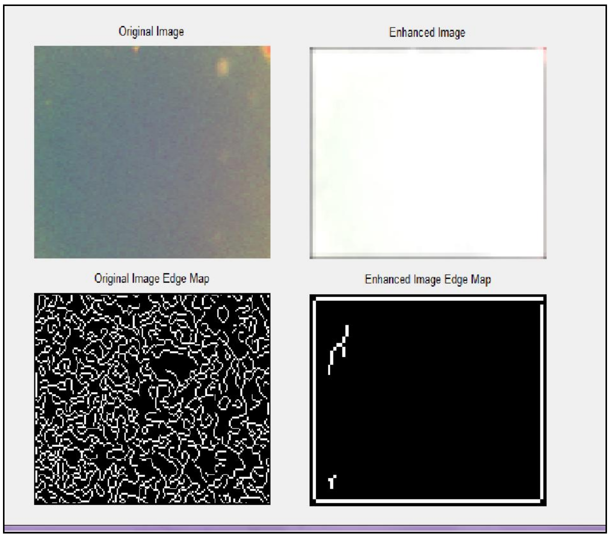

Figure 9: Results of Fifth experiment (Liquid - Milk +1/3 Water)

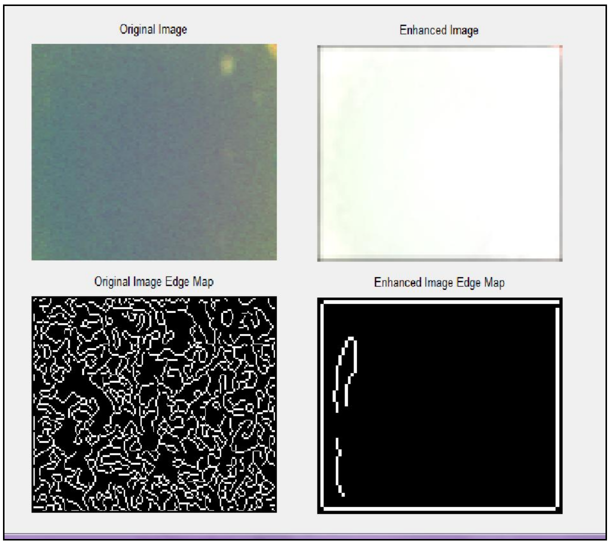

Figure 10: Results of Fifth experiment (Liquid – ½ Milk + ½ Water)

First three experiments are performed to test the performance of the proposed system. In first experiment shown in figure.5, gives the original infrared image of liquid as water and the enhanced infrared image using the algorithm as well as its edge map. It is observed that the proposed sensor system with enhancement algorithm has enhanced the visual quality of liquid and its edge map.

Second three experiments are performed to test the performance of the proposed system which is shown in figure 8, which again give the original infrared images and enhanced infrared images for liquid as Milk and milk with impurity.

A similar experiments are carried out for another sample of liquid Water and Milk with some impurity and the results are shown in figure 6 , Figure7, Figure 9 and Figure 10. It is clear that the peak signal to noise ratio (PSNR) of impure liquid is always less as compared to pure liquid.

VI. CONCLUSION

This paper draws our attention to a new approach for infrared image enhancement. This approach clubs the additive wavelet transform and the homomorphic enhancement features. Each infrared image subbands are subjected to homomorphic processing separately. To reconstruct an enhanced image these subbands are merged again. The results obtained using this algorithm reveal its ability to enhance infrared images.

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