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# The Classification of Fetus Gender Based on Fuzzy C-Mean Using a Hybrid Filter

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**Abstract.** This paper proposes a new approach, of Clustering Ultrasound images using the Hybrid Filter (CUHF) to determine the gender of the fetus in the early stages. The possible advantage of CUHF, a better result can be achieved when fuzzy c-mean FCM returns incorrect clusters. The proposed approach is conducted in two steps. Firstly, a preprocessing step to decrease the noise presented in ultrasound images by applying the filters: Local Binary Pattern (LBP), median, median and discrete wavelet (DWT), (median, DWT & LBP) and (median & Laplacian) ML. Secondly, implementing Fuzzy C-Mean (FCM) for clustering the resulted images from the first step. Amongst those filters, Median & Laplace has recorded a better accuracy. Our experimental evaluation on real data from the Kadhimiya teaching hospital shows that the proposed CUHF is a better method when compared to the accuracy of the other integrated filters.

**Keywords:** Fuzzy C-mean, Filters Integration, Noise Reduction, Fetus Gender.

## 1. Introduction.

Many studies have focused on the use of fuzzy logic techniques to improve medical diagnostics [1]. The fuzzy c-mean algorithm (FCM) [2] is one of the most famous algorithms which can assist in decision-making [3]. [4] Proposed a novel approach to measure the muscle thickness from ultrasound images of the lumbar area to diagnose low back pain effectively. [5] Used robust Optimal GLCM features linked to FCM segmentation algorithm which is employed to cluster the kidney cysts and tumor from the ultrasound kidney images. However, others applied filters before implementing FCM to reduce the speckle in ultrasound images to obtain better results.

Filters play a major role in the pre-processing step which could assist researchers to reduce the noise of images [6]. Other studies also used filters for enhancing ultrasound images [7]. [8] Adopted a special study on "noise reduction" by using a wiener filter and discrete wavelet transform in a homomorphic region. The use of the Weiner filter and wavelet conversion is utilized to reduce the noise of ultrasound [8]. Besides, (LBP) local binary pattern operator to provide the classification Ultrasonic Thyroid of HOG Features [9]. A median filter is used in artifact removal in radiological ultrasound images [10]. In addition, several studies reported that filters can be useful to improve the FCM algorithm. For example, [11] used LBP with fuzzy c-mean to extract features in underwater images. [12] Integrated wavelet into FCM for



reconstructing morphological grayscale of sparse regularization. Moreover, improved malignant diagnosis using FCM based on the improved median of lung images [13].

In this study, we propose CUHF a new approach for improving the performance of FCM by using such an algorithm that tries different applied filters as preprocess on Ultrasound images. The proposed approach uses single and combination filters until the CUHF records the highest accuracy. The design of our approach was to detect the gender of the fetus by extracting selected features. Many difficulties were challenged such as the complexity of uterine tissue and the similarity of the fetus features were difficult to distinguish. Kadhimiya teaching hospital was selected because pregnancies attend the sonar department to do regular checks. The test of pregnant mothers was conducted to obtain the source of medical images for educational purposes. The images include related features from the ultrasound device (UD) during the second and third trimester of pregnancy. Our initial experimental results show that the CUHF approach achieves a better accuracy when the ML filter is applied and compared to those obtained when using FCM and other used filters.

## **2. Pre-Processing & Filters Applied to CUHF Approach**

This section describes the used filters to reduce the noise of ultrasound images. These filters are applied to reduce the noise to enhance the performance of the FCM algorithm. Ultrasound images contain a noise which may cause damage conditions because of variation of the velocity with beam frequency. Therefore the preprocess step contains a series of image enhancement stages that can be listed as follows: noise removal, segmentation, and normalization. To remove the noise associated with the ultrasound image, a suitable filter will be applied to reduce the noise and maintain the original details of the image. Images are next partitioned into multiple segments for object recognition. Ultimately, the images are normalized into the range of pixel intensity of 256 x 256. The difference between the edges and the noise will produce a frame (3\*3) into the next candidate filter.

### **2.1 Local Binary Pattern (LBP)**

LBP is a local binary pattern that works as a character revealer can be executed on ultrasound images. The basic algorithm idea can be described as two-parent surface textures. The native operator classifies pixels of the image by specifying the 3 x 3 (LBP) of each pixel with the value of the center and a result is a binary number, (LBP) as classification or fragmentation properties by applying a summation of the probability of fabric pattern in the histogram [14]. The reason for the failure of the LBP in the classification is because it is influenced by the contour, which is often a "high contrast".

First, When LBP is applied to the ultrasound images; the proposed CUHF approach converts them into greyscale. Secondly, it divides the examined frame into cells 3x3 pixels. Third, compare the pixel to each of its 8 neighbors". Follow the pixels clockwise or counterclockwise. If the center pixel's value is greater than the neighbor's value", then the value is 1 else value is 0. "After computing this for every neighbor pixel, the values are listed in a clockwise manner and the equivalent decimal value is calculated". Finally "Once done for every pixel, the values are grouped in 256 bins and the histogram is created", the output is the enhanced filter.

### **2.2 Discrete Wavelet Transform (DWT)**

Is an easy-to-implement conversion in which wavelets are sampled instead of separate DWT. It is important to use because the transform uses a Fourier transform instead of using a fixed-width frame, DWT as well as the time it takes to calculate a conversion very quickly compared to a Fourier transform that takes more time, the conversion depends mainly on the wavelet matrix, which can be calculated faster than the Fourier matrix. The method of hiding information can also be used as DWT [15], [16]. The process of converting wavelets is a simple idea. The original image is divided into 4 new sub-images. Each sub-image is (25%) the original image by analyzing each image in different frequency bands with varying degrees of accuracy.

Each image is decomposed by four levels using the separate wavelet conversion at each level. (HH, HL, LH) and Details (LL) Transactions, Rounding The sub picture appears in the upper right, lower left, and lower right as an approximation of the original image because it contains high-frequency components of the original image. As for the upper left sub-picture, it appears as the original image and looks smoother, with the lower frequency components of the original image [17].

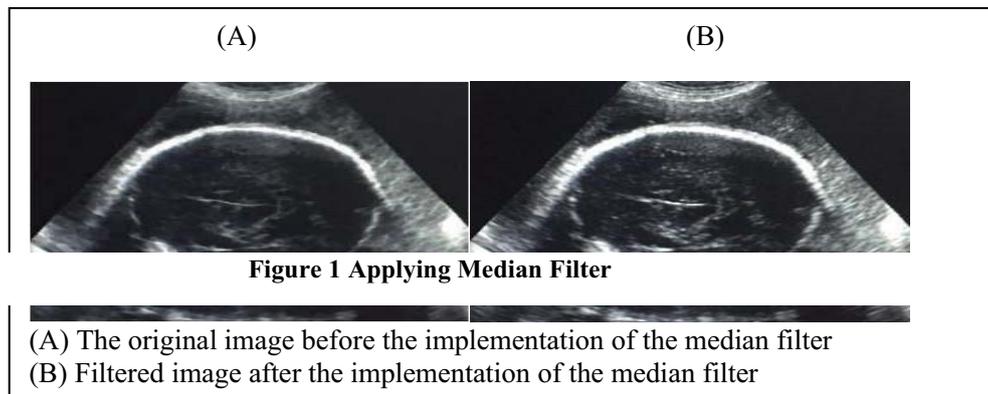
### 2.3 Median Filtering

Median and Nonlinear digital filtering is mostly used for noise removal of "spots" from ultrasound images [18]. This method is effective and widely used in digital image processing because it maintains sharp edges when noise is removed [19]. It calculates the median by sorting all pixel values from surrounding neighborhoods in the numerical approach and then replaces corresponding pixels with the pixel value. The median is also provided the simplicity of eliminating noise when compared with other filters. Especially for ultrasound images, this filter is very important [18].

Table1 Unsorted Vectors

1	0	0
0	8	7
5	29	14

Taken the above example, unsorted vectors are (1, 0, 5, 0, 8, 29, 0, 7, 14), sorted vector are (0, 0, 0, 1, 5, 7, 8, 14, 29) Median value is 5. It is noted in Figure 1 that the images contain a higher percentage of noise than the image (B) resulting in the results as shown below:



When the median filter is applied to the proposed CUHF, an Input of 256\*256 ultrasound images is obtained. In the first step, the entire matrix of the image pixel is padded with zeros or ones on all sides. Second, the frame will be an array, store the 3\*3 neighbor value in the array, and sort the neighboring pixels into order. Finally, replace the value of a center pixel with the median value from the list, the enhanced filter is obtained.

### 2.4 Laplacian Filtering

Laplacian is considered as a two-dimension isotropies' measure of the second spatial derivative of an image. It highlights areas of fast intensity change and consequently often utilized for edge detection with the technique of zero-crossing edge detectors. This filter is frequently applied on images that have first been smoothed with something approximating a Gaussian filter to reduce its sensitivity to noise. Therefore the two variants will be labeled together. A single gray level image is normally taken as an input and generates another gray level of the image as output [20]. The Laplacian  $L(x,y)$  of an image with pixel intensity values is,  $x$  &  $y$  are random variables,  $\varnothing$  = an integral transform that converts a function of a real

variable,  $I$  = integral maps a function from original to function space, the equation of Laplacian is given below :

$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \quad (1)$$

#### Equation 1 Laplacian Intensity Metric [21]

Because the input of the image appears as a set of discrete pixels, a discrete convolution kernel can be approximated as second derivatives. Thus, in the definition of the Laplacian, small kernels could be relatively sensitive to noise. The image is preferably Gaussian smoothed before applying the Laplacian filter. This pre-processing step decreases the high-frequency noise contents before the differentiation step. The combination of filters could lead to better results. [22] Proposed hybrid filter of image processing approach which improves the Gabor function to execute the image classification. [23] Suggested a new speckle-noise reduction algorithm in medical ultrasound images by combining a wavelet transform and Laplacian filter. [24] suggested a hybrid median filter as a noise removal based non-linear filter for image enhancement. It is suggested for Gaussian noise removal from the medical image. The introduced hybrid filtering technique is for the removal of Gaussian noise from medical images. The research conducted on extracting skeleton on Kinect images [25] supported the idea of combining filters to reduce the noise and obtain better performance. This encouraged the researcher to try combining median and Laplacian filters to remove the noise and detect edges of ultrasound images.

#### 2.5 Feature Extraction

Extracting features is the most important step in image classification. It helps to extract the attribute of the image as perfect as possible. [26] Described that the extraction of features of visual information from the image and saves properties oriented in the database features. The feature extracting is originated to extract visual information from the image and save oriented properties in the database features. Extract feature finds the image description in the form value feature for each pixel. For a given image, the GLCM (Gray-Level Co-Occurrence Matrix) works by calculating how often pairs of pixels are made in images and then extracting statistical measures from that matrix, in a given space relationship. Features can be derived from the original image to be combined with the GLCM features. The derived from an image that has been optimized and used as features to cluster the fabric of digital images [27]. The features are useful for clustering and retrieving similar images and provide information on the distribution properties of the density level of the Image. The tissue attributes are extracted from the common presence matrix and the mathematical equations are given the textile profiles as shown in the algorithm of [28].

In addition, the original selected features of the fetuses are bi-parietal diameter (BPD), femur length (FL), Liquor, Placenta, FH+ve, uterine wall contraction, congenital anomaly, longitudinal lie, single or twin, contrast, entropy, diabetes. Moreover, the age of pregnancies was taken between (15 - 40) weeks of pregnancy.

#### Feature Extraction Algorithm:

Input: Number of image of ( mxn) gray scale image.

Output: 12 features.

Step 1: Select data set of image.

Step 2: Construct GLCM for images.

Step 3: Calculate feature from GLCM.

Step 4: Put all feature in matrix.

Step 5: Normalize feature.

Step 5.1: Calculates mean, variance, standard deviation, skewness for each feature.

### 2.6 Fuzzy C – Mean Algorithm

Data mining algorithms have been used for improving many fields [29]. One of the most useful algorithms is FCM. It is a method of clustering in which each data can be assigned to more than one cluster. It involves allocating data points to clusters for instance items in the same cluster are as similar as possible, while items fitting to different clusters are as dissimilar as possible. These similarity measures contain distance, connectivity, and intensity. In hard clustering, data belong to different clusters, where each point can only belong to precisely one cluster. In fuzzy clustering, data points can belong to many clusters. Membership scores are allocated to each of the dataset points (tags). These membership scores refer to the degree to which data points fit each group. Therefore, points on the edge of a cluster, with higher membership scores, could be in the cluster to higher scores than refers in the center of the cluster. FCM has been a very significant approach for image processing in clustering objects in images. In the last decades, mathematicians presented the spatial term into the FCM algorithm to develop the accuracy of clustering under noise [30].

Enhanced FCM has been utilized to distinguish between different actions using image-based features [31]. As a result, FCM is still the most spread for its practical success which can discover the basic skeletons of data that are used in many engineering and scientific fields for example medical images and search for biological data [32].

### 3. Proposed approach: CUHF to Enhance the Performance of Clustering.

This stage was performed through collecting images after the ethical approval is obtained of pregnancies in the maternity hospital. An experimental methodology has been utilized to obtain the best results. The used filters in the first experiments were produced unsatisfactory results because of low accuracy. All filters are applied before implementing the FCM algorithm to remove noise as shown in Figure 2. We first applied the LBP filter but undesirable results were obtained. Thus, to improve the performance of FCM, we second applied the Median filtering technique on these images as a pre-processing step of noise reduction. Afterward, Median & DWT are applied to the CUHF approach, the accuracy went slightly better. (Median, DWT & LBP) are examined to obtain good results but undesirable accuracy is gained by this integration. As shown in CUHF Algorithm, the attempt was to try one or a combination of the determined filters to obtain the best results. After the selected features are extracted the CUHF allocates the number of clusters i.e.  $C_n$ . In addition, the approach chooses the appropriate level of membership of fuzziness  $m > 1$ . After initializing the partition matrix randomly  $U$ , the Calculation of the centers of Vector ( $C^k$ ) will be completed. Calculate the Euclidean distance ( $D_{ij}$ ) to update fuzzy membership matrix  $U_{ij}$ , if the distance is less than the membership  $\epsilon$  the approach must be stopped otherwise it should return to the step of calculating the centers of Vectors. The best results are obtained by the proposed (Median & Laplacian) ML when compared to other applied filters. The combination of filters is to enhance the performance of clustering. ML is an integration of non-linear and linear filters. The attempt was to remove the noise using the Median filter and then pass the result to the Laplacian filter to allocate the fetus's edges. ML produces better results for noise reduction, preservation of structures and key details. The Hybrid Filter is used for de-noising and smoothing images as shown in Figure 3 (B), whereas in the same figure (A) the image is still distorted. The filter fits in with the local variation and the performance of the smoothing feature extraction.

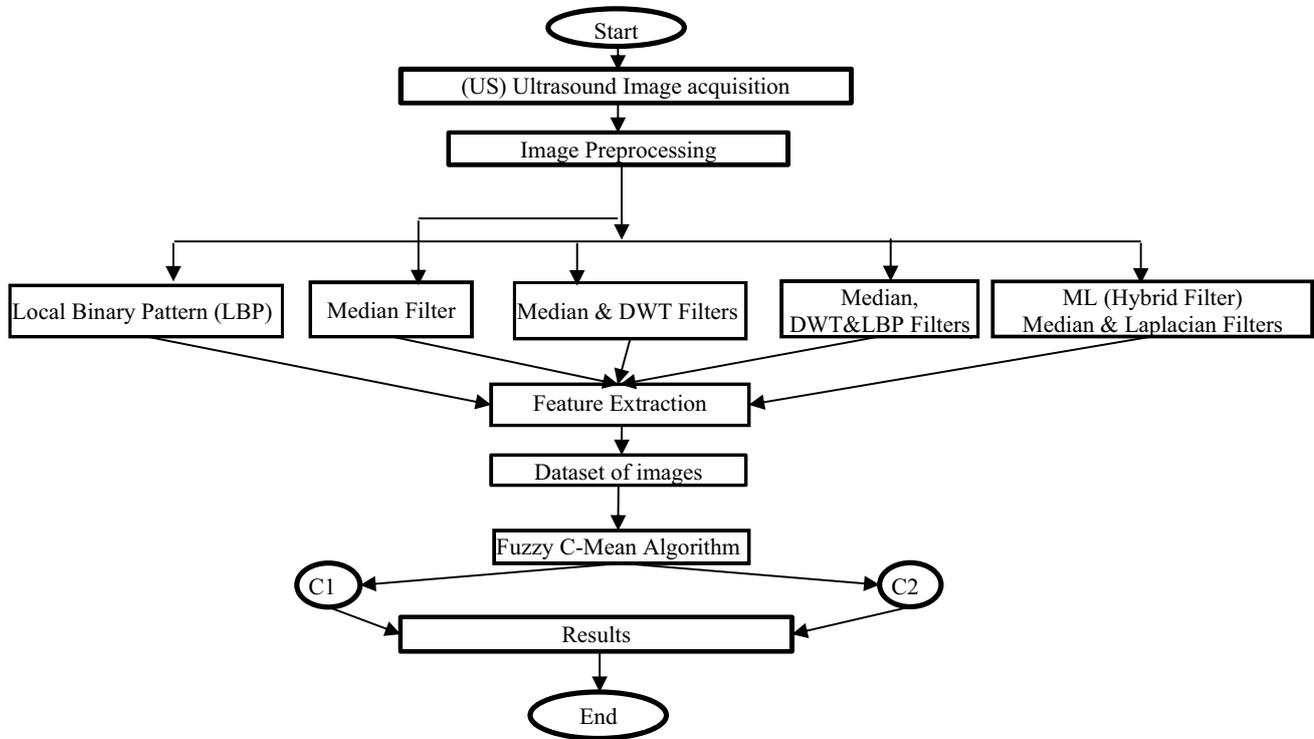


Figure 2 The Proposed System CUHF

#### 4. Results and Discussions

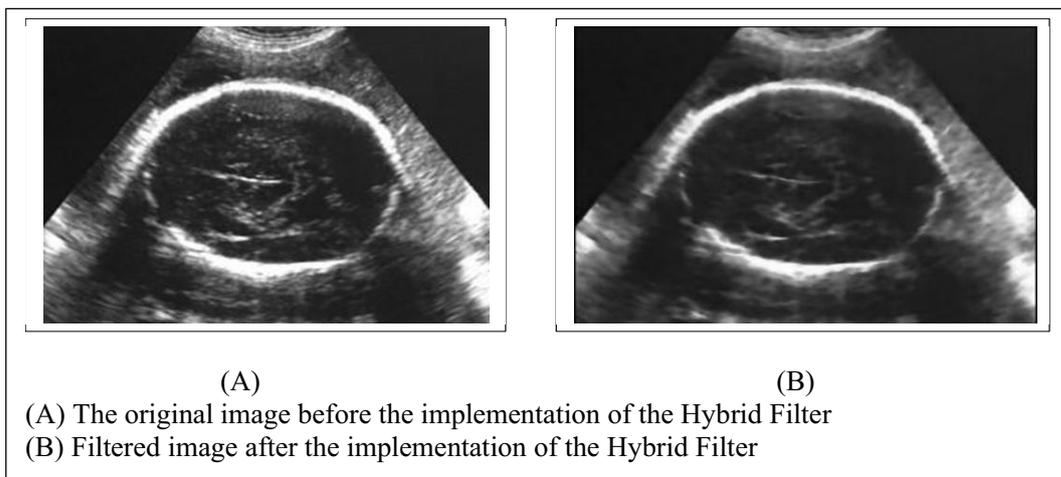


Figure 3 Applying Hybrid Filter

To examine the accuracy of CUHF, tests were carried out using a dataset gained from Kadhimiya teaching hospital.

**Algorithm: CUHF**  
 Input dataset: 100 ultrasound images.  
 Preprocess (Try filters):

- 1- LBP.
- 2- Median.
- 3- Median & DWT.
- 4- Median, DWT & LBP.
- 5- Median & Laplacian (ML).

Feature Extraction (FL, BPD, Liquor, Placenta, FH+ve, uterine wall contraction, congenital anomaly, longitudinal lie, single or twin).  
 Dataset of images.  
 Fuzzy c-mean:

- 1: select the data set of feature extraction.
- 2: Select the number of clusters  $C_n$ .
- 3: Select an appropriate level of cluster fuzziness  $m > 1$ .
- 4: Initialize the partition matrix randomly, such that  $U = [u_{ij}]$  matrix,  $U^{(0)} \in M^f c$ .
- 5: Calculate the cluster centers Vector  $C^{(k)} = [C_j]$  with  $U^{(k)}$ , using the expression given below:
- 6: Calculate the Euclidean distance
- 7: Update fuzzy membership matrix.  $U$  according to  $D_{ij}$ . if  $D_{ij} > 0$ , then STOP; otherwise return to step 5

Results: c1 or c2

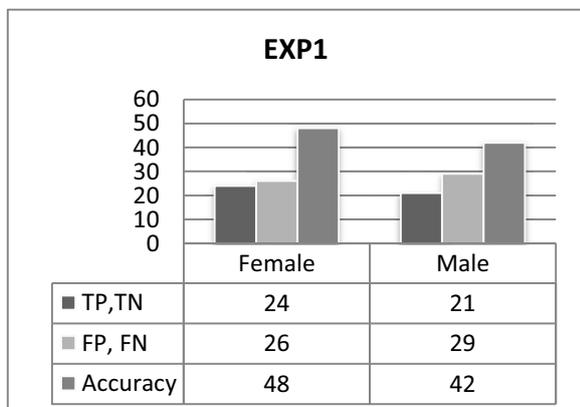


Figure 4 LBP Results

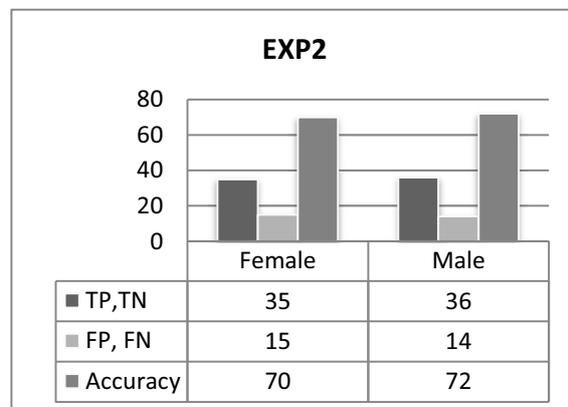


Figure 5 Median Filtering Results

In the conducted experiments, the results of CUHF approach will be illustrated as a clustering of the fetal sex, the determination of the ultrasound images is divided into 2 clusters. In addition, a total of 100 images of the ultrasound device were used to measure the features dimensions 50 males and 50 female. This section highlights the implementation of LBP, DWT, and combination of (Median & DWT), (Median, DWT&LBP) and (Median & Laplacian) filters, and how the best results are obtained.

Figures displayed in the results section are to show the outcomes of the experiments conducted on the proposed approach. It starts with the experiments of LBP and ends with the hybrid ML filter till the research reached reasonable outcomes. For all charts, The “Accuracy” recaps the evaluation of FCM after applying a filter of LBP, Median, Median & DWT, (Median, DWT & LBP), and proposed ML. TP, FP, TN, FN refer to True Positive, False Positive, True Negative, and False Negative respectively. In addition, Cluster1 and Cluster2 represent the images of the females and males respectively.

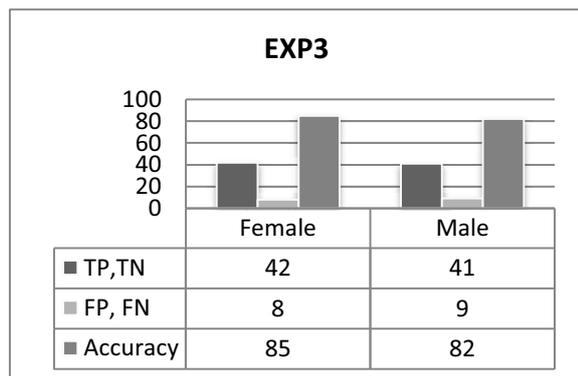


Figure 6 Median & DWT’ Filtering

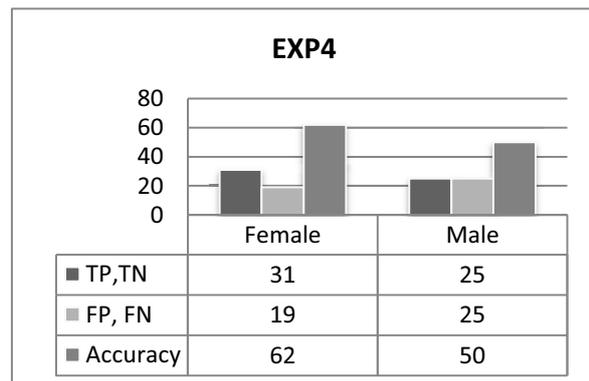


Figure 7 Median, DWT& LBP Filtering

The initial experiment was conducted on the FCM algorithm to obtain reasonable clusters. FCM algorithm on its own returns 20 TP & 19 FP which records 40% and 38% respectively. This research attempts to enhance the performance of FCM by improving accuracy.

Experiment1: the bar chart in Figure 4 shows the accuracy of the LBP filter. From the chart, it clear that cluster1 consists of (24) images which are clustered as a TP, whereas 26 of them are clustered as a FP wrongfully. The Accuracy summarizes the evaluation of LBP respectively 48%, which is lowest among the conducted experiments. Also, Cluster2 returned a 21 TN and 29 FN of males with an accuracy of 42% which gave unsatisfactory results. Therefore more experiments are needed to obtain better results.

Experiment 2: From the chart in Figure 5, it is noticed that the accuracy of Median Filtering is 70% with 35 TP and 15 FP wrongfully clustered images, cluster1. In addition, in Cluster 2, 36 are clustered as a TN and 14 FN with an accuracy of 72%. This gave a better accuracy compared to Experiment 1.

The third experiment is conducted using Median & DWT filters. The outcomes show that cluster1 consists of 42 TP whereas 8 are categorized as FP with an accuracy 85% as shown in Figure 6. Also, 41 TN and 9 FN of males are clustered with an accuracy of 82%, this gave a better accuracy compared to experiments 1 and 2.

The Fourth experiment (Median, DWT&LBP) is integrated. Figure 7 shows the results of cluster1 which consists of 31 TP images, 19 FP with an accuracy of 62%. Clusters contained 25 TN and 25 FN which indicates 50% accuracy. This outcome refers to the worst results compared to experiments 2 and 3 but better than 1, which indicates that LBP could cause non-preferred results due to produce rather long histograms, which slow down the recognition especially on image database.

In the fifth experiment, when the Median & Laplacian filter is applied to the CUHF approach, the outcomes of cluster1, cluster2 consist of 45 TP, 5 FP, 47 TN, and 3 FN with the accuracy of 90% and 94% respectively as shown in Figure 8. This gives the highest accuracy when compared to all the conducted experiments in this study.

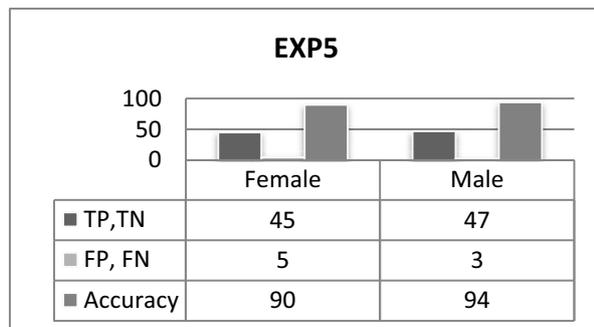


Figure 8 ML Hybrid Filtering

The result in experiment 5 showed that the best method of clustering was obtained from the application of the ML hybrid filter. The implementation of the median filter and Laplacian filter has directed the experiments to the highest accuracy. In experiment 5, total accuracy in both Cluster1 and Cluster2 was higher than the results obtained in experiments 1, 2, 3 and 4.

Besides, when using the median filter, the results were fairly good compared to LBP. (Median & DWT) filter, the results were better compared to the accuracy when using the (Median, DWT & LBP), because it is affected by the contours that are often (High Contrast). The greatly improved accuracy rate is obtained in the proposed ML filter when the union of median and discrete wavelet was employed to match a target of enhanced ultrasound images. The CUHF approach is presented with a path to take this research further.

## 5. Conclusion and Recommendations

This paper has presented a new approach, CUHF, to improve the performance of FCM clustering. The CUHF approach uses a new hybrid filter ML as a process that produces far fewer clustered images than would be produced from basic FCM. It uses a new approach to extracting important features to determine the gender of the fetus in ultrasound images. The best ratings were obtained from the images for the ML filter and the inability of the LBP images to give correct clustering. The experimental results have shown that the advantages of CUHF over classic FCM when unrelated images are clustered. The outcome of the

CUHF approach, cluster1, cluster2 returned 45 TP, 5 FP, 47 TN, and 3 FN with the accuracy of 90% and 94% respectively. This gives the highest accuracy when compared to all the conducted experiments in this study. It is recommended to consider other methods such as Fourier Transform as well as the adoption of other prediction algorithms e.g. SIFT to reduce the dimension in the field of clustering. Also, the Fuzzy Neural Network for clustering fuzzy images can be used for a training net that can predict the gender of the fetus in the early stages to obtain better results.

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