Breast cancer image enhancement with the aid of optimum wavelet-based image enhancement using social spider optimisation

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Abstract: This paper is to enhance features and gain higher traits of breast cancer images utilising optimum wavelet-based image enhancement (OWBIE) with social spider optimisation (SSO). More than a few biomedical images are of low quality and difficult to detect and exact information. The converted gray pictures are utilised for filtering approach; here optimum wavelet-based image enhancement with social spider optimisation, histogram equalisation, anti-forensic distinction enhancement process and curvelet centred distinction enhancement are used. The proposed technique is used to remove noise and hold area moderately sharp in the fed enter images. In the results, more than a few mean absolute error (MAE), mean square error (MSE), root mean square error (RMSE), peak signal to noise ratio (PSNR) and structural similarity index measure (SSIM) evaluation metrics graphs are analysed and enhanced. This proposed process performed better in comparison with different enhancement techniques.

Keywords: optimum wavelet-based image enhancement; OWBIE; social spider optimisation; SSO; breast cancer.

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1 Introduction

Cancer is a type of disorders that make the cells of the body to alternate its features and cause the odd development of cells (Kumar et al., 2013). Breast cancer is establishing at now a champion among the many most commonly recognised diseases among women within the made world. The adequacy of breast cancer screening making use of mammography has been mainly targeted in view that the mid-1960s (Menendez et al., 2010). The breast cancer is the real medical disorders as it is the primary driver of dying among the many entire sorts of disorder specifically for ladies that too at the age of 35 to 55 years. Thus, a long way no known techniques are there to keep a strategic distance from breast cancer. Be that as it is going to, the pleasant solution to care for distinguish the breast cancer at the earlier stage will provide extra benefit to the impacted peoples (Venkatesan and Velmurugan, 2015). Breast cancer can easily impact women, whose neighbourhood blood relatives have this illness (mom, sister, and daughter) (Gowri and Amudha, 2014). Breast malignancy is mostly of two sorts: Invasive and Non-invasive. Invasive type is the one wherein malignant cells wreck by way of normal breast tissue boundaries and unfolds to more than a few parts of the body. While in non-invasive, harmful cells stay in a detailed vicinity of the bosom and don't unfold to incorporating tissue, ducts or lobules (Ali and Feng, 2016). It is common to recognise the malignant cell before it spreads to quite a lot of organs, along these strains the survival price for the sufferer will augmentation to greater than 97% (Zribi and Boujelbene, 2016).

Breast disease screening must be feasible using unusual imaging techniques. Essentially the most naturally comprehended screening philosophy is the mammography. This kind of imaging process is a certain type of radiography that utilises radiation lower than those of normal radiography, for example, activities X-ray (Helwan and Abiyev, 2015). In various international locations, breast cancer movements improved amid the 20th century, to a first-rate extent reflecting overall changes in reproductive patterns and regional increments in mammography (Salama et al., 2012). Mammograms are utilised to

look at the early stage and routine checkups shrink the chance recognised with loss of life. An uncommonly basic type of imaging utilised for the screening of breast melanoma is mammography. All women at threat come upon mammography screening framework for early disclosure and finding of the breast cancer (Jenita and Devadoss, 2016). In this sense, an image enhancement assumes a significant section to lessen the noise level of the image, preserving important predominant points and enhancing the contract to improve the detection of mammographic features (Makandar and Halalli, 2015).

Enhancement of contrast in medical images utilising image processing techniques expands the accuracy and efficiency of the radiologists in deciphering the tissue facets in medical images (Gandhamal et al., 2017). Accordingly, handling individual RGB image channels extra often than not prompts colour distortion or fading and various plans had been devised within the literature to correct this deficiency (Nnolim, 2018). More than a few adaptive unsharp masking strategies were proposed in the literature to work with varying amount and direction of blurring (Bhagat et al., 2014). The direct enhancement algorithms which were depicted are to an excellent distinction enhancement methodology, in that their point is to most of the time increment the measured distinction (Nercessian et al., 2013). Accuracy is common in the classification of medical data; a hybrid method has been shown to overhaul the classification accuracy of breast cancer (Lavanya and Rani, 2012). Countless algorithms motivated by way of the insects and animals habits to resolve a broad type of complex optimisation problems. The improved social spider optimisation (SSO) algorithm depends upon the re-enactment of the cooperative behaviour of social-spiders is proposed to optimise our problem (El Soud and Anter, 2016).

The paper is organised as follows: in Section 2, existing methods have been discussed. The proposed scheme is explained in Section 3. Results are discussed in Section 4. The conclusions are given in Section 5.

2 Literature review

Kharel et al. (2017) advised to increase utilising hybrid solution for early diagnosis of breast cancer using mammogram images. From the experiment, hybrid image enhancement approach making use of CLAHE and morphology system helps to enhance the image for assist computation in CAD framework to early diagnosis of breast cancer making use of mammogram images while maintaining processing time as the prior excellent answer. From the investigation, delineate that the purposed answer can help to increase mammogram images for the extra processing for segmentation, feature extraction and classification. In any case, additional testing and implementation of suitable classification procedure required for before clinical utilise.

Ravi et al. (2016) advocated that detecting contrast enhancement (CE) in images and anti-forensic methodologies against such finders have elevated much consideration in multimedia forensics as of late. A couple of distinction enhancement detectors analyse the most important request measurements, for example, grey-level histogram of images to decide whether or not an image was once CE or not. To counter these detectors specific anti-forensic techniques had been proposed. Formulate an optimisation issue using a variation of the extraordinary total variation (television) norm image restoration formulation. Trials demonstrate that the algorithm accurately conquers the primary and

2nd ordered statistics headquartered detectors without loss in quality of the enhanced images.

Akila et al. (2015) proposed CE was a crucial issue in the area of mammographic image processing. It was once characterised into two courses: direct CE and indirect CE. Indirect CE includes in changing histogram of the image. Histogram equalisation (HE) used to be primarily the most oblique CE approach, which was broadly utilised for CE. Numerous editions of HE had been proposed thus far. Evaluation of those techniques used to be altogether principal in determining a proper algorithm for enhancement and further processing. In that paper, they related few indirect CE approaches in certain HE, CLAHE, BBHE, RMSHE, MMBEBHE to pre-process the mammographic pix. The execution of the methods was measured using an effective measure of enhancement (EME) and height peak signal to noise ratio (PSNR).

Cuevas et al. (2013) required to suggest that swarm insight will probably be an examination field that modes the whole direct strategy over swarms of bugs then again creatures. A number of algorithms developing beginning with such models had suggested dealing with a large sort of complex optimisation problems. In that paper, a swarm algorithm referred to as that SSO had prescribed to acknowledging development assignments. These algorithms perceive two uncommon search dealers (spiders): women and men. These examinations break down a few commonplace benchmark works that will regularly observe inside the fashioned works about evolutionary algorithms. These conclusions display a non-compulsory execution of the endorsed framework for looking a worldwide foremost with a pair of benchmark works

Xue et al. (2010) predicted early detection of breast melanoma used to be plainly a key detail of any system meant to decrease breast cancer mortality. That paper tested second iteration curvelet grow to be coefficients, modified by way of nonlinear operators, can reconstruct mammography and make more evident scarcely observed elements of mammography to distinguish breast melanoma more early and safely. The brink security index and the distinction improvement index were utilised to examine the satisfactory of proceeded photo regions containing validated lesions. Results of the trial show the effectiveness of the process.

3 Materials and methods

The principle purpose of this investigation is to increase features and gain better traits of medical images for a right analysis. Medical images were mostly poor indeed in contrast. For solving this challenge, optimum wavelet-based image enhancement (OWBIE) with SSO is utilised.

3.1 Optimum wavelet-based image enhancement

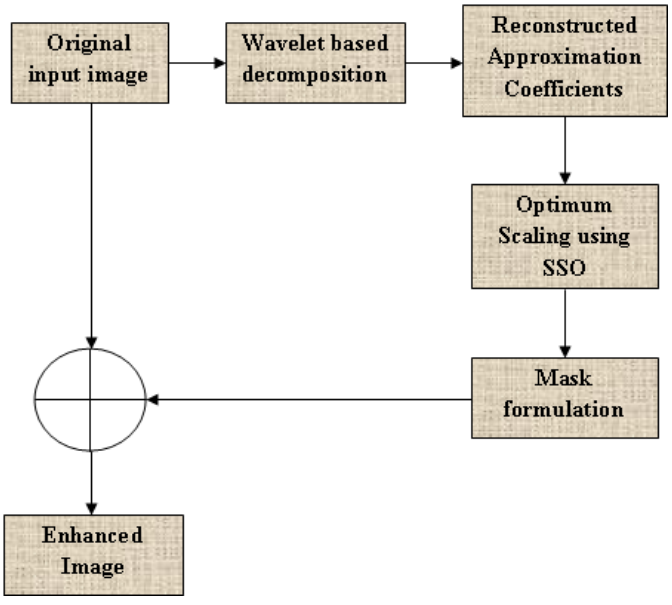
The input medical breast images are decomposed as the approximation, vertical, horizontal and diagonal coefficients, utilising equation (1). The approximation coefficients are inverse discrete wavelet transformation (IDWT), as precise in equation (2). The resulting is top of the line scaled utilising the proposed optimisation algorithm referred to as SSO. The formulated optimum mask can adaptively control the contrast of the input medical images.

$$W_{\varphi}(s_o, p, q) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y)\, \phi_{so,p,q}(x, y) \tag{1}$$

$$f^{A}(x, y) = \frac{1}{\sqrt{MN}} \sum_{m} \sum_{n} W_{\varphi}(so, p, q)\, \phi_{so,p,q}(x, y) \tag{2}$$

where $W_{\varphi}(s_o, p, q)$ is the approximation coefficients, represents the scale coefficients, m, n is the wavelet domain discrete elements, φ is the arbitrary initial scale value. In which, $f(x, y)$ is the input spatial image with discrete variables x, y with size $M \times N$, $s_o = 0$, φs_o, p, $q(x, y)$ is the scale function and $f^{A}(x, y)$ is the reconstructed approximation image. The block diagram of proposed OWBM is given in Figure 1.

Figure 1 Block diagram of OWBM (see online version for colours)



3.1.1 SSO algorithm

In this paper, for elevating a new swarm optimisation algorithm the operational standards from the social-spider colony have been used as principles. The SSO think that the entire search area is a communal web, where all of the social-spiders interface to each other. On this social spider algorithm, there are two distinctive spiders: ladies and men. Each individual is directed by an assortment of special transformative administrators, which reproduce numerous cooperative behaviours which might be more often than not estimated within the colony, depending on genders.

The extremely female-biased populations are an interesting normal of social-spiders. The algorithm starts with the aid of characterising the quantity of feminine and male spiders as a way to be characterised as participants in the search space. The number of females NSi_f is arbitrarily chosen inside the range of 65–90% of the whole population NSi. In this way, NSi_f is calculated by the additional equation:

$$NSi_f = floor\left[(0.9 - rand.025).NSi\right] \tag{3}$$

Wherever rand is a random number between [0, 1] where floor ( ) maps a real number to an integer number. The number of male spiders NSi_m is calculated as the complement between NSi and NSi_f. It is computed as follows:

$$NSi_m = NSi - NSi_f \tag{4}$$

Accordingly, the complete population Si_p, composed by NS_i elements, is divided in two sub-groups F and M.

Initialisation

In this initial step, randomly initiate the whole population (female and male). The algorithm starts by initialising the set Si_p of NSi spider positions. Such values are haphazardly and consistently conveyed between the pre-specified lower initial parameter bound py_j^{low}, and the upper initial parameter bound py_j^{high}, likewise as it portrayed by the associated expressions:

$$f_{i,j}^0 = py_j^{low} + rand(0,1).\left(py_j^{high} - py_j^{low}\right) \quad (i = 1, 2, \ldots, NSi_f,\ j = 1, 2, \ldots n) \tag{5}$$

$$m_{k,j}^0 = py_j^{low} + rand(0,1).\left(py_j^{high} - py_j^{low}\right) \quad (k = 1, 2, \ldots, NSi_m,\ j = 1, 2, \ldots, n) \tag{6}$$

where j, i and k are the parameter and individual lists discretely whereas zero signals the initial population. The function rand (0, 1) produces an arbitrary number between 0 and 1. Therefore, $f_{i,j}$ is the j^{th} parameter of the i^{th} female spider position. At that point, compute the radius of mating

$$r = \frac{\sum_{j=1}^{n}\left(py_j^{high} - py_j^{low}\right)}{2.n} \tag{7}$$

The randomly generated initial solutions are coefficient value range (–1 to 1) and the number of solution length is 8 where 4 as wavelet transform and 4 as inverse wavelet transform.

After generate the solutions in this above format and then find the fitness function expressed underneath section.

Fitness function

In the proposed approach, every individual (spider) receives a weight w_i which characterises the solution quality that corresponds to the spider i (irrespective of gender) of the population S_i.

The fitness function is exposed beneath and the value of R is 255.

$$PSNR = 10 * \log_{10} \frac{R^2}{MSE} \tag{8}$$

In order to calculate the weight of every spider the next equation is used:

$$w_i = \frac{J\left(Si_{pi}\right) - worst_{Si_p}}{best_{Si_p} - worst_{Si_p}} \tag{9}$$

where $J(Si_{pi})$ is the fitness value acquired by the evaluation of the spider position Si_i with consider to the objective function $J(.)$. The values $worst_{sip}$ and $best_{sip}$ are defined as follows (considering maximisation):

$$best_{si_p} = \max_{k\in\{1,2,\ldots N\}}\left(J\left(Si_p\right)\right) \text{ and } worst_{si_p} = \min_{k\in\{1,2,\ldots N\}}\left(J\left(Si_p\right)\right) \tag{10}$$

Modelling of the vibrations through the communal web

The communal web is utilised as a component to transmit data amongst the colony members. The vibrations depend upon the weight and distance of the spider, which has produced them. In order to repeat this process, the vibrations saw by the individual i because of the information transmitted by the member j are established by the associated equation:

$$Vib_{i,j} = w_j . e^{-d_{ii,j}^2} \tag{11}$$

where the $d_{i,j}$ is the Euclidian distance between the spiders i and j, such that $d_{i,j} = ||Si_{pi} - Si_{pj}||$.

Cooperative operators

In this cooperative operator method, two types of operators are explained underneath such as female and male cooperative operators.

Female cooperative operator

In order to emulate the cooperative behaviour of the female spider, a new operator is characterised. The operator considers the position change of the female spider i at every iteration. Such position change, which can be of attraction or aversion, is figured as a mix of three unique components. The first includes the change concerning the nearest member to i that holds a higher weight and delivers the vibration $Vibf_i$. The second one considers the change in regards to the best individual of the whole population S_i who delivers the vibration $Vibg_i$. Finally, the third one fuses a random improvement.

$$Vibf_i = w_f . e^{-d_{i,f}^2}, \quad Vibg_i = w_g . e^{-d^2{}_{i,g}} \tag{12}$$

A uniform random number r_m is created inside the range [0, 1]. On the off chance that r_m is smaller than a limit PF, a fascination development is created; generally, a repugnance development is delivered. Consequently, such operator can be displayed as takes after:

$$f_i^{k+1} = \begin{cases} f_i^k + \alpha.Vibf_i.\left(Si_{pf} - f_i^k\right) + \beta.Vibg_i.\left(Si_{pg} - f_i^k\right) \\ +\delta.\left(rand - 1/2\right) \text{ with proability } PF \\ f_i^k - \alpha.Vibf_i.\left(Si_{pf} - f_i^k\right) - \beta.Vibg_i.\left(Si_{pg} - f_i^k\right) \\ +\delta.\left(rand - 1/2\right) \text{ with proability } 1-PF \end{cases} \tag{13}$$

where α, β, δ and rand are arbitrary numbers between [0, 1] while k represents the iteration number. The individual Si_{pf} and Si_{pg} represent the nearest member to i that holds a higher weight and the best individual of the whole population S_i, separately.

Male cooperative operator

Male individuals, with a weight value above the median value inside the male population, are viewed as the predominant people *D*. Then again, those under the median value are marked as non-dominant *ND* males. So as to perform such calculation, the male population *M* ($M = \{m_1, m_2, \ldots, m_{NSdm}\}$ is organised by their weight an incentive in diminishing request. The vibration $Vibh_i$ viewed by that individual $i(D_i)$ because of the data passed on by the part $h(D_h)$ with h consistently the nearest female unmistakable to i.

$$Vibh_i = w_h.e^{-d_{i,h}^2} \tag{14}$$

Since lists of the male population *M* concerning the whole population Si_p are expanded by the number of female members NSi_f, the median weight is recorded by NSi_{f+m}. As per this, change of positions for the male spider can be demonstrated as takes after:

$$m_i^{k+1} = \begin{cases} m_i^k + \alpha.Vibh_i.\left(Si_{pf} - m_i^k\right) + \delta.\left(rand - 1/2\right) & if\ w_{NSi_{f+i}} > w_{NSi_{f+m}} \\ m_i^k + \alpha.\left(\dfrac{\sum_{h=1}^{NSi_m} m_h^k.w_{NSi_{f+h}}}{\sum_{h=1}^{NSi_m} w_{NSi_{f+h}}} - m_i^k\right) & if\ w_{NSi_{f+i}} \le w_{NSi_{f+m}} \end{cases} \tag{15}$$

where the individual S_{rf} represents the nearest female individual to the male member i whereas $\left(\sum_{h-1}^{NSim} m_h^k \cdot WNSif + h \Big/ \sum_{h-1}^{NSim} WNSif + h\right)$ correspond to the weighted mean of the male population *M*.

By utilising this operator, two distinct behaviours are delivered. To start with, the set *D* of particles is attracted to others in order to provoke mating. Such behaviour permits fusing assorted qualities into the population. Second, the set *ND* of particles is pulled to the weighted mean of the male population *M*. This reality is utilised to mostly control the search process according to the average performance of a subgroup of the population. Such mechanism acts as a filter, which avoids that very good individuals or extremely bad individuals, influence the search process.

Mating process

In the mating procedure, the weight of each included spider (elements of T_g) characterises the probability of impact for every person into the new brood. The spiders holding a heavier weight will probably impact the new item, while elements with lighter weight

have a lower probability. The impact probability P_{Sipi} of each member is appointed by the roulette strategy, which is characterised as takes after:

$$p_{Si_{pi}} = \frac{w_i}{\sum_{j \in T^k} w_j} \quad where\ i \in T^g \tag{16}$$

Once the new spider is framed, it is compared with the new spider candidate Si_{pnew} holding the worst spider Si_{pwo} of the colony, as per their weight values [where $w_{wo} = \min_{l \in \{1,2,\ldots,NSi\}} (w_l)$]. On the off chance that the new spider is better to the worst spider, the new one replaces the worst spider. Something else, the new spider is disposed of and the population does not suffer changes. If there should be an occurrence of substitution, the new spider assumes the gender and index from the replaced spider. Such actuality guarantees that the whole population Si_p maintains the original rate between female and male members. Under this operation, new generated spiders locally abuse the search space inside the mating range in order to discover better individuals. For discovering best solution, the fitness calculations are occurred and find a best new spider.

4 Results and discussion

In this section, for enhancing the breast cancer images various techniques are utilised such as OWBIE, HE, anti-forensic CE technique, and curvelet-based CE. Table 1 shows the original images and different CE images using OWBIE, HE, anti forensic CE technique and curvelet-based CE. Table 2 demonstrates the evaluation metrics such as mean absolute error (MAE), mean square error (MSE), root mean square error (RMSE), PSNR and structural similarity index measure (SSIM) for proposed OWBIE technique.

Table 1 Original images and different CE images

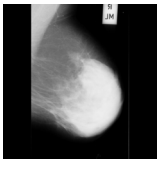
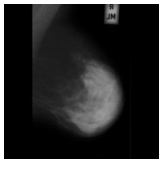
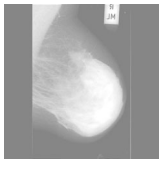
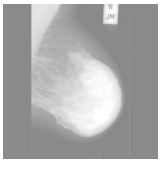
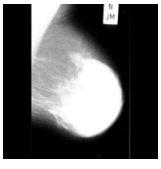
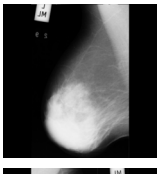
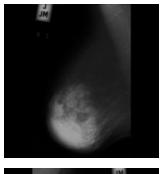
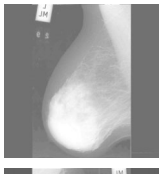
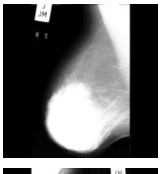
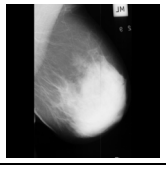
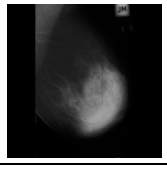
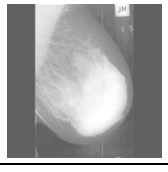
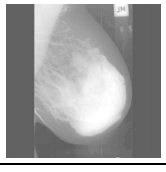
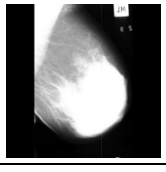
Original image	*Anti-forensic contrast enhancement technique*	*Curvelet-based contrast enhancement*	*Histogram equalisation*	*Optimum-wavelet-based image enhancement*
				
				
				

Table 1 Original images and different CE images (continued)

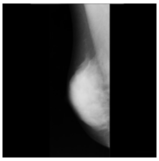
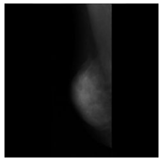
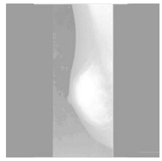
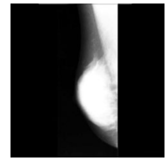
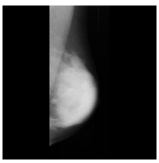
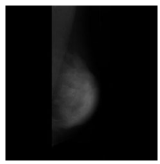
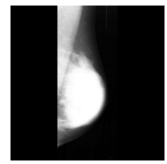
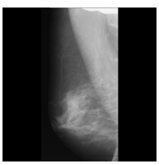
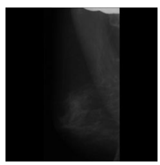
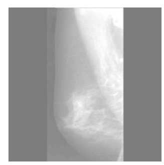
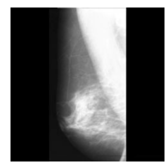
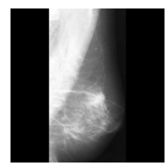
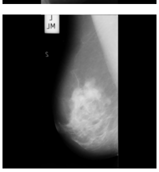
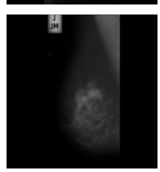
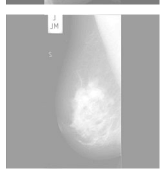
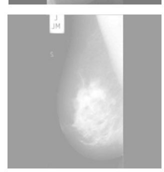
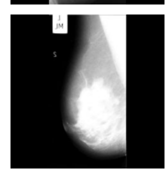
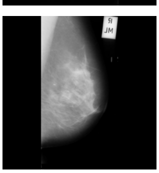
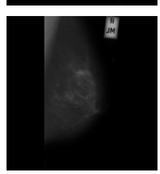
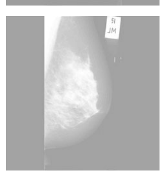
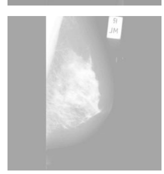
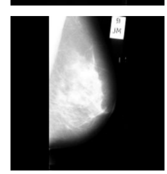
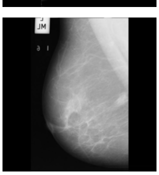
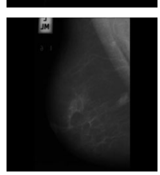
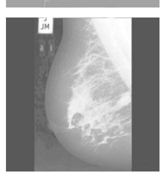
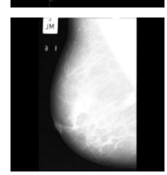
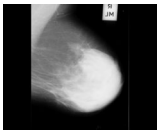
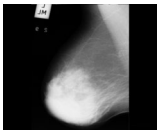
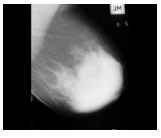
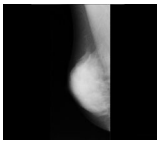
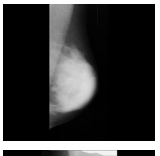
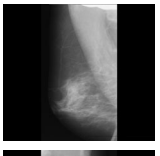
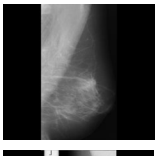
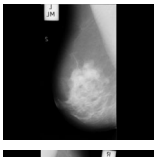
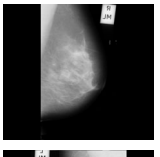
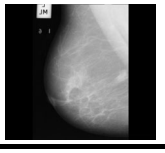
Original image	*Anti-forensic contrast enhancement technique*	*Curvelet-based contrast enhancement*	*Histogram equalisation*	*Optimum-wavelet-based image enhancement*
				
				
				
				
				
				
				

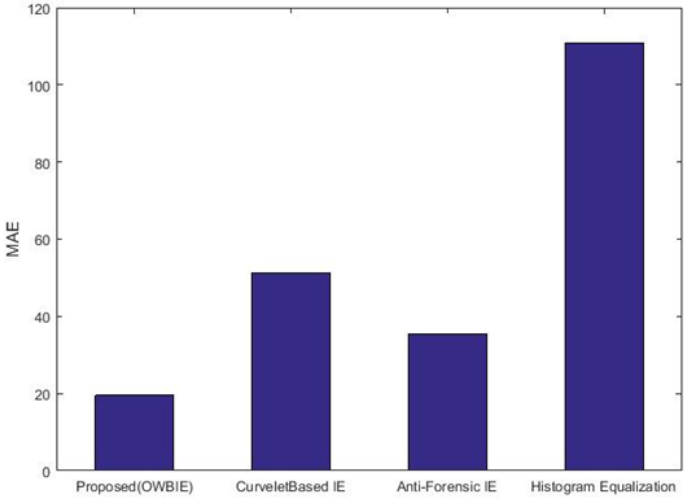
Table 2 Evaluation metrics for proposed enhancement technique

Original image	*MSE*	*PSNR*	*MAE*	*RMSE*	*SSIM*
	33.74481	32.84873	20.00034	33.74481	0.800565
	34.95304	32.69595	20.78645	34.95304	0.785098
	34.74601	32.72175	21.51928	34.74601	0.794051
	26.40557	33.91385	11.24291	26.40557	0.883941
	26.26867	33.93642	11.57194	26.26867	0.894271
	36.18157	32.54593	21.42781	36.18157	0.747336
	35.56709	32.62032	21.22173	35.56709	0.757427
	33.75231	32.84777	18.27201	33.75231	0.81059
	34.1946	32.79123	17.79031	34.1946	0.818759
	43.6794	31.72804	28.4061	43.6794	0.703962

4.1 Mean absolute error

The MAE value for proposed OWBIE with SSO is 20%, HE is 110%, anti forensic CE technique is 38% and curvelet-based CE is 50% shown in Figure 2. From these calculations, the proposed technique is performed better.

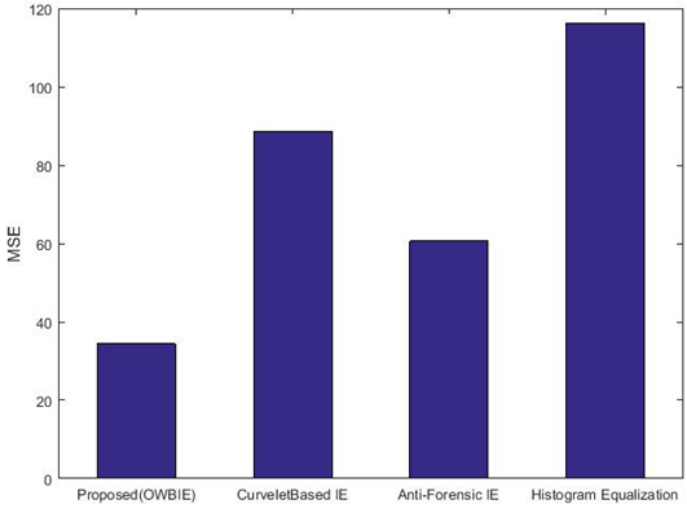
Figure 2 MAE graph for enhancement techniques (see online version for colours)



4.2 Mean square error

The MSE value for proposed OWBIE with SSO is 38%, HE is 118%, anti forensic CE technique is 60% and curvelet-based CE is 90% shown in Figure 3 From these calculations, the proposed technique is performed better.

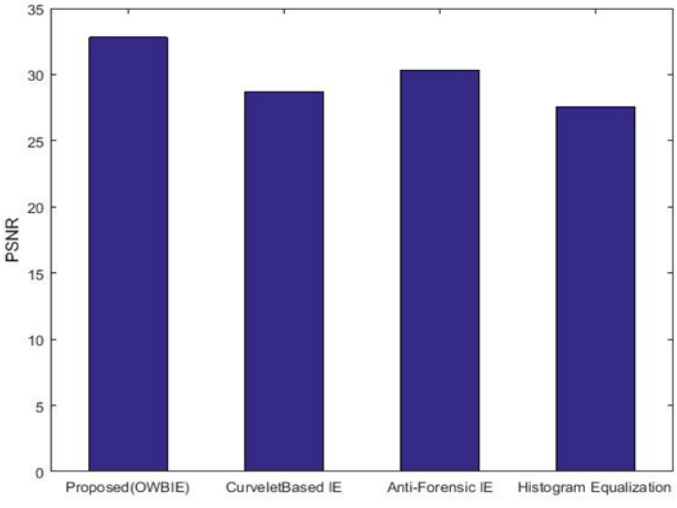
Figure 3 MSE graph for enhancement techniques (see online version for colours)



4.3 Peak signal to noise ratio

The PSNR value for proposed OWBIE with SSO is 33%, HE is 27%, anti forensic CE technique is 29% and curvelet-based CE is 90% shown in Figure 4. From these calculations, the proposed technique is performed better.

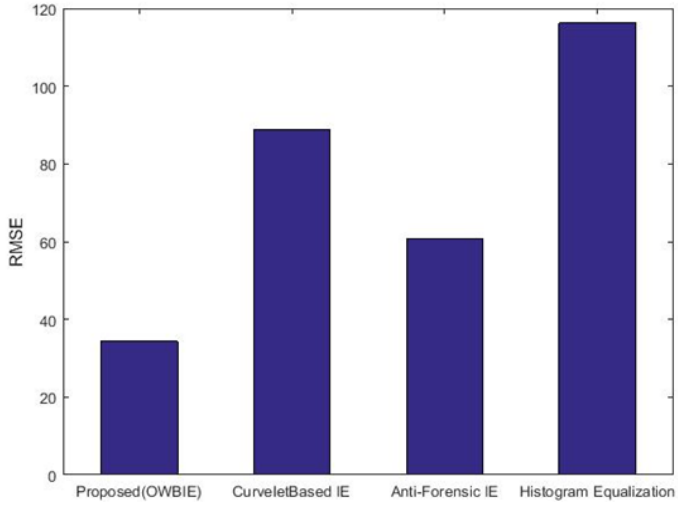
Figure 4 PSNR graph for enhancement techniques (see online version for colours)



4.4 Root mean square error

The RMSE value for proposed OWBIE with SSO is 35%, HE is 118%, anti forensic CE technique is 60% and curvelet-based CE is 90% shown in Figure 5. From these calculations, the proposed technique is performed better.

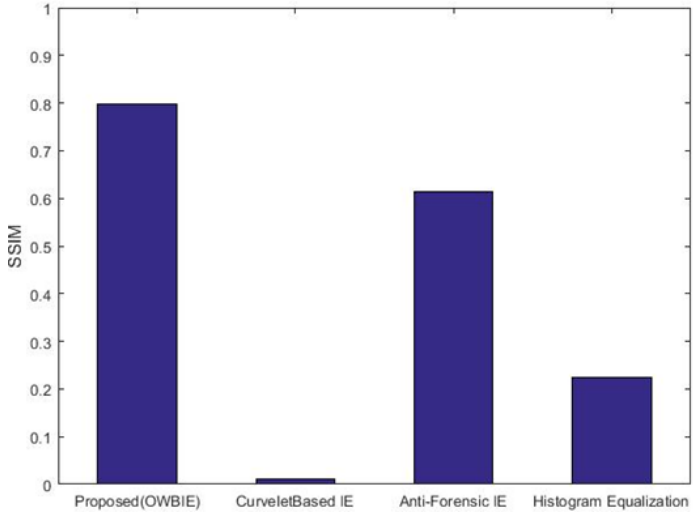
Figure 5 RMSE graph for enhancement techniques (see online version for colours)



4.5 Structural similarity index measure

The SSIM value for proposed OWBIE with SSO is 0.8%, HE is 0.22%, anti forensic CE technique is 0.62% and curvelet-based CE is 0.001% shown in Figure 6. From these calculations, the proposed technique is performed better.

Figure 6 SSIM graph for enhancement techniques (see online version for colours)



5 Conclusions

Presently breast cancer is the most common cause of death in women and the second leading cancer deaths worldwide. Primary prevention in the early stages of the disease becomes complex as the causes remain almost unknown. In this paper, an approach is proposed for effective breast cancer image enhancement which makes use of digital mammogram images based on the OWBIE with SSO. The results show that the proposed method outperforms the existing methods in terms of MAE, MSE, RMSE, PSNR and SSIM. In future, different optimisation algorithms based on swarm intelligence can be used to further improve the quality of digital mammograms.

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