International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1, October, 2019

Segmentation of Low Contrast Satellite and Medical Images Based on Level Set Function with Harmony Search Optimization Algorithm

Rangu Srikanth, Kalagadda Bikshalu

Abstract: ***The main aim of digital image segmentation for portioned the image in to its constituents parts for getting information regarding features of image also used to get pathological details from medical images. The literature available from last two decades the important scheme for image segmentation is with Level Set technique, multilevel thresholding of gray scale on histogram of image is also a traditional method of image segmentation. In this paper low contrast images from medical and satellite images considered for image segmentation to extract features. This paper puts forward a novel image segmentation method via Level Set Function along with Bi-Histogram Equalization based on Harmony Search Algorithm(LSFBHEHS). The Selective Binary and Gaussian Filtering Regularised Level Set (SBGFRLS) is efficient novel region based Active Contour Model, it uses a novel region-based signed pressure force (SPF) function, it can adeptly halt the contours at blurred edges and weak edges. Other important advantage is internal and external boundaries can be distinguished by fixing the initial contour may be anyplace in the considered image. This method is resourceful but requires more time and inefficient for segmentation of low contrast images. This problem is rectified by applying bi-histogram equalization(BHE) image enhancement method prior to Level Set, it can be treated as pre-processing. In BHE technique of image enhancement, the image histogram is partitioned into two divisions based optimized gray level threshold , and equalize each part of histogram separately and combined later. To find the optimized threshold level to slice the histogram into two parts, Otsu's multilevel thresholding method used to find threshold level, to find optimized thresholding level Harmony Search Algorithm(HSA) is implemented to maximize inert class variance as objective function. For evaluating the proposed method and SBGFRLS, the qualitative measured used like Dice similarity index, Measure of Enhancement(EME) and time required, for experimentation numerous low contrast satellite and medical images are considered, results clarified that the proposed method is more efficient for low contrast and inhomogeneous images.***

Keywords: Digital Image Segmentation, Otsu's method, Bi-Histogram Equalization, Harmony Search level set function, signed pressure force,.

I. INTRODUCTION

The digital image segmentation is important image processing scheme which can be for division of digital image into numerous number of regions; a region can be defined as which is a homogeneous areas by satisfying criteria of some similarity[1].

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

Rangu Srikanth B.Tech in Electronics & Communication Engineering from JNTUCE, Kakinada, JNTU, Hyderabad,

Dr. Kalagadda Bikshalu Ph.D degree in Electronics & Communication Engineering from JNTUH, Hyderabad.

Abstractly methods for image segmentation can be separated into two groups (i) edge-based segmentation based on discontinuity of intensity levels (ii) region based image segmentation search for homogeneity[2] within a region. Different algorithms are devised in last two decades for the segmentation. A partial differential equation(PDE) and variational model based techniques are used, for detecting regions and boundaries in image, curve evolution procedures are used as active contour models(ACM) as [3]-[6]in this paper. The concept of this way is, a closed line or curve termed initial curve C is exposed on the image, this curve progresses or evolves to reach the boundaries and objects of image with the help of certain properties of digital image like dissimilarity of gray levels, colours and curvature etc, there are various methods of evolution of curve is available in literature. Initially contour evolution is devised by Kass, Witkin and Terzoupolus[7]- [8] reformed by Caselles with help of Level Set Function(LSF), the first technique is Geometric active contour [13] model depends on geometric flow of curve and Caselles et al. [9]-[10] devised the Geodesic active contour model (GAC), this technique is a supervised model given by Paragios [11], Chan and Vese presented the new ACM for images which are not having edges [12].

II. INTRODUCTION TO ACM

Kasset developed that snake [14] of active contour model(ACM) for segmentation, initially as shown in Fig.1 intial level set or zero level set fixed on the image to cover specified are then propagate into entire are of image to identify different regions. In this process there are two forces anticipated (i) internal force is to keeping the model additional smoothly for evolution period (ii) external force depends on intensities specified to moving the contour nearby boundaries. The simple method utilised for trace the curve on the image using level set is likewise as used in snake model, initially splitting or merging of curve faces difficulty for of parametric form of methods. The remedy for above shortfall mentioned above, the implicit ACM used as alternate to explicitly. LSF is more effective in the propagation or execution of active contour.

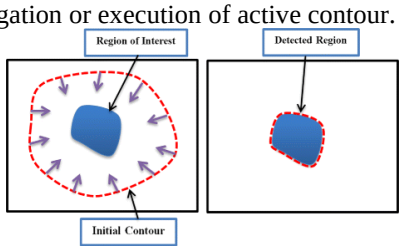


Fig.1: Zero LSF of Initialization of Contour

III. LEVEL SET FUNCTION(LSF)

As given in [12] initially two scientist Sethian and Osher devised LSF, which performance as numerical tool for spreading of initial level set function in the direction of various regions or objects, used to identify the edges and regions as shown in[13].

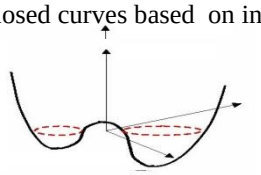
Let C is initial or zero level set function of LSF $\emptyset$, a parameter called signed distance function (SDF) used by initial level set to spread over the image. For initial curve C the functional values are initialised by zero for pixels those are on C. The sign assigned as negative for outside area of the contour and sign is positive for area inside the contour.

$$\emptyset(x,y) = \pm d\big((x,y),C\big) \tag{1}$$

From (1) $d\big((x,y),C\big)$ is distance from C to any pixel point (x,y), the initial contour or interface is describes as

$$C = \{(x,y)/\emptyset(x,y) = 0\} \tag{2}$$

throughout movement of contour curve changes its shape to identify the regions or objects, a case given in Fig.2, the initial curve as in Fig.2 (a) is evaluated and becomes in two closed curves based on intensity or grey level discontinues.



C (t=0) level set Fig.2. (a) Initial LSF or Curve

***C (t) level* set** Fig.2. (b) Curve Evolution at t

The PDE is mathematical tool for spreading of Level Set Function ($\emptyset$) with respect to time, $\emptyset = \emptyset((x,y),t)$, this function contain hyperbolic or parabolic terms, for improved performance consider a known speed term F, which is accurately right angle to curve C, with this speed curve can propagate in outside and inside. This curve is a set of function of $\Phi\big(\Phi\big(C\big((x,y),t\big),t\big) = 0\big)$, it can be expressed as below

$$\frac{\partial\Phi(x,y)}{\partial t} + \nabla\emptyset\frac{\partial C((x,y),t)}{\partial t} = 0 \tag{3}$$

this equation of LSF announced by Osher and Sethain[13] given below as

$$\frac{\partial\Phi(x,y)}{\partial t} = F|\nabla\emptyset| \tag{4}$$

As shown in(4) the F term is one of the specification given by designer, constant speed, for pulling or pushing the contour to outside or inside, div($\nabla\emptyset/||\nabla\emptyset||$) is the curvature of the level set function of Φ passing through position(x,y) .The ACM with mean curvature[7] is given as

$$\frac{\partial\Phi(x,y)}{\partial t} = |\nabla\emptyset(x,y)|\big(\varepsilon\kappa\big(\Phi(x,y)\big) + \nu\big) \tag{5}$$

From (5) the term ν is constant for correction to maintain the value of $(\nu + \varepsilon\kappa\big(\Phi(x,y)\big)$ positive, the term ν defined as pushing force for LSF or contour in the direction of several regions or objects , when the value of (5) zero the flow of LSF or curve ends. The term ν>0 is a constraint in inside the curve area, and propagation speed is proportional to ν.

Where κ term is mean curvature of LSF formulated as

$$\kappa\big(\emptyset(x,y)\big) = div\left(\frac{\nabla\emptyset}{||\nabla\emptyset||}\right) \tag{6}$$

$$\kappa\big(\emptyset(x,y)\big) = \frac{\emptyset_{xy}\emptyset_y^2 - 2\emptyset_x\emptyset_y\emptyset_{xy} + \emptyset_{yy}\emptyset_x^2}{\big(\emptyset_x^2 + \emptyset_y^2\big)^2} \tag{7}$$

From (7) the $\emptyset_x$ and $\emptyset_{xx}$ represents first and second order derivatives of $\emptyset(x,y)$ with respect to x, similarly $\emptyset_y$ and $\emptyset_{yy}$ derivatives for $\emptyset(x,y)$. From (7) the term ε maintains the regularity of evolution robustness and process.

For GAC proposed by Caselles as in [8] given a new function named stopping function to steer the speed function, given in (8)

$$\frac{\partial\Phi(x,y)}{\partial t} = g\big(I(x,y)\big)(\varepsilon\kappa + \nu)|\nabla\emptyset(x,y)| \tag{8}$$

As shown in above $g(I(x,y))$ indicated the stopping function, the simpler from of g $g(I(x,y))$ is as below(9)

$$g\big(I(x,y)\big) = \frac{1}{1+|\nabla I(x,y)|} \tag{9}$$

The curve stops its propagation in image as $g\big(I(x,y)\big)$ faded to zero, as tern ν increases the speed of flow of contour also increases [7], where κ term for maintain is curvature term for regularity of curve C. This (9) is modified by Caselles et al [9] , this model is given

$$\frac{\partial\Phi(x,y)}{\partial t} = g\big(I(x,y)\big)\big(\kappa\big(\Phi(x,y)\big) + \nu\big)|\nabla\emptyset(x,y)| + \nabla g\big(I(x,y)\big).\nabla\emptyset(x,y) \tag{10}$$

Chan and Vese presented as in [12] a new model named Piecewise- constant Active Contour which is based on model of Mumford-Shan. In this C-V method contour flows with energy minimizing function for search of edges in images, C-V model for LSF as give below

$$\frac{\partial\Phi(x,y)}{\partial t} = \delta_\varepsilon(\emptyset(x,y))\left[\nu\kappa\emptyset(x,y) - \{(I(x,y)-\mu_1)^2 - (I(x,y)-\mu_0)^2\}\right] \tag{11}$$

From (11) μ_1 and μ_0 denotes means of image gray levels inside and outside area of contour C.

IV. SBGFRLS FUNCTION

Finally a novel method of levels set model as given [13] is SBGFRLS used signed pressure force as stopping function[14].

A. The Signed Pressure Force (*SPF) function*

Its value ranges [-1, 1], the SPF as given below

$$spf\big(I(x,y)\big) = \frac{I(x,y) - \frac{c_1+c_2}{2}}{\max\left(\left|I(x,y) - \frac{c_1+c_2}{2}\right|\right)} \quad (x,y) \in C \tag{12}$$

From(12) c_1 and c_2 are the mean gray levels inside and outside area of C. From (11), pixels inside and outside the object are homogeneous, it is important[14] to know that $\min(I(x) \leq c_1$, $\max(I(x)) \leq c_2$ and there is

$$\min(\mathrm{I(x)}) < \frac{c_1+c_2}{2} < \max(\mathrm{I(x)}) \quad (13)$$
$$\mathrm{x} \in \mathrm{C}$$

Finally (12) is modified as

$$\frac{\partial \Phi(x,y)}{\partial t} = spf(I(x,y)).\left(div\left(\frac{\nabla\emptyset}{|\nabla\emptyset|}\right) + \alpha\right)|\nabla\emptyset| + \nabla spf(I(x,y)).\nabla\emptyset \quad (14)$$

In the previous level set methods uses SDF as its interface to prevent it from being too steep and flat near its interface, it required re-initialization, re-initialization is expensive technique. Aa remedy for this problem[14], use a Gaussian filter to regularize the selective binary level set function after each iteration, this new model uses advantages of both CV GAC[15].

B. Advantages of SBGFRLS *model*

This model uses statistical information from image to stop the curve flow, it used SPF for local and global segmentation, this is not possible by earlier models and more robust to different types of noises. It can detect the boundaries with weak edges like MRI medical images. This model can propagate to entire area of the image by placing the initial level set anyplace on the image, it can work efficiently for non-inhomogeneous images also.

V. BI-HISTOGRAM EQUALIZATION

A. *Introduction*

There is major a problem exits in the images taken for remote sensing applications from satellites, for medical images also[16], the reflectance values of sensors not matching abilities of the colour or monochrome display of a system. Materials or any other structures on the Earth emit and reflects different energy levels. A sensor of satellite might record a huge amount of energy form a material in given wavelength, whereas other material of a structure may record with less amount of energy in the same range of wavelength. In this case image enhancement can be useful to extract various features clearly from a non-homogeneous satellites images, this case is true for medical images also. The important method of image enhancement is contrast enhancement, in this the range of gray levels collected originally from satellite or medical images are transformed into other set of pixel values to enhance the visual quality.

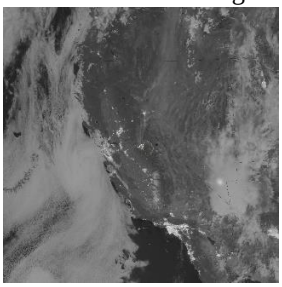


Image.1: Satellite Image


Image.2: Satellite Image

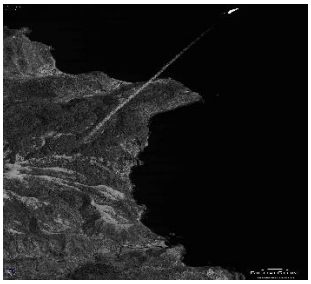


Image.3: Satellite Image

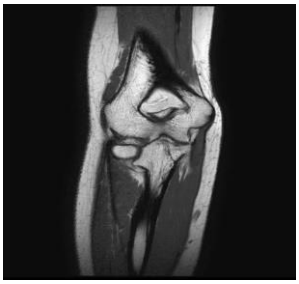
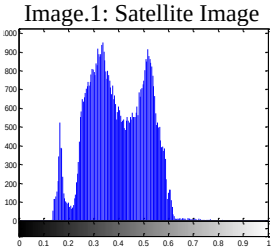
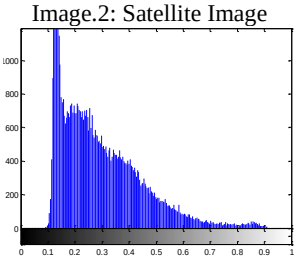
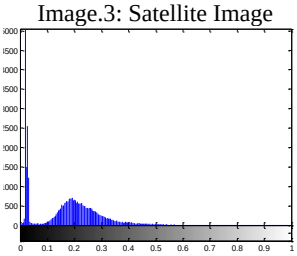


Image.4:MRI of Elbow


Histogram of Image.1


Histogram of Image.2


Histogram of Image.3

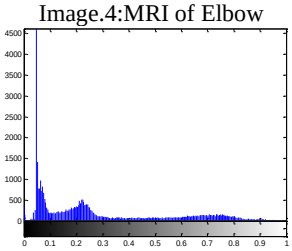

Histogram of Image.4


Image.5:MRI of Knee


Image.6: MRI of Lower Extremities (Leg)

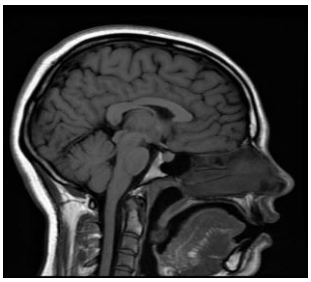


Image.7: MRI of Scan of Brain

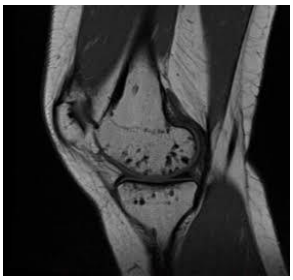
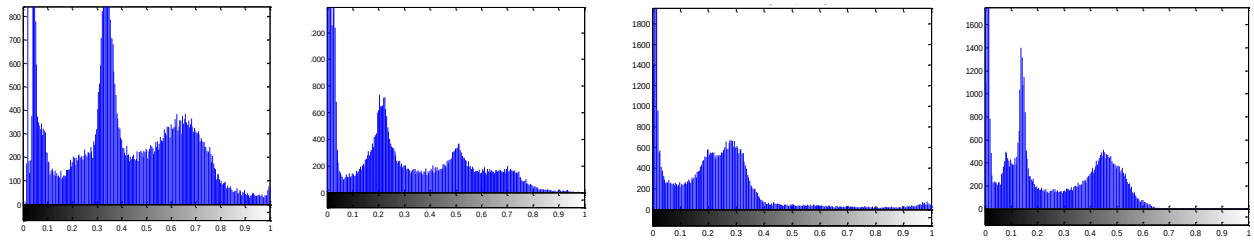


Image.8: MRI of OSTEOPOIKILOSIS



Histogram of Image.5 Histogram of Image.6 Histogram of Image.7 Histogram of Image.8

Fig.3: First and Third rows are input images used for experimentation, Second and Fourth rows are histograms above images

B. *Bi-Histogram equalization*

The Contrast Enhancement[16]-[17] is a technique of changing the pixel value ranges in a images to in order to increase contrast. From various methods available methods for image enhancement, Histogram Equalization (HE) is widespread method specially for low contrast medical and satellite image enhancement, this HE can also be used for speech recognition, object tracking, etc. In spite of many advantages of HE, there is a shortfall also involved, this method maintain the average of pixel values before and after process of HE, consequently either oversaturation or undersaturation results enhanced images. As a therapy for this problem a new model of histogram equalization called bi-histogram equalization (BHE) is used[18], which divides the histogram into two sub regions called sub-histograms. For improving the efficiency of bi-histogram equalization, the thresholding between two parts of histogram is computed by Otsu's method based bi-level thresholding by maximising the inter class variance. In this paper Harmony Search Algorithm(HSA) method utilised to compute optimized threshold level by maximizing the inter class variance.

VI. LEVEL SET EVOLUTION BASED ON HARMONY SEARCH ALGORITH

Otsu's technique is one of the popular technique for find the threshold which divides the entire pixels in images in to two groups, bi-level thresholding, by maximising the inter class variance. After applying technique of bi-level thresholding of input image $I(x,y)$, then it is modifies as $I_{BHE}(x,y)$, on which the final (14) is applied for Level Set Evolution to generate segmented image, which is more efficient as compared to SBGFRLS function directly applied on $I(x,y)$.

A. *Harmony Search Algorithm*

In HSA, the possible solutions[19]-[20] (or elements in solution space) is termed a "harmony", which is a n-dimensional real vector. As similar to any optimization technique, in HSA also random values are assigned to initial population and loaded in harmony memory (HM). In next step, evaluated new candidate(nest generation or iteration) harmony is produced from considered the elements in HM either by adjusting the pitch or by random selection for updating the elements in HM, as a final step the elements in harmony memory by comparing the worst HM vector and newly computed candidate harmony, this whole process is repeated number of times in order to satisfy termination condition. The HSA having below three steps.

The first step is problem statement and variables of algorithm can be briefly as, Minimization or maximization of $f(x), x = (x(1), x(2), \ldots\ldots x(n)) \in R^n$, in HSA maximization of function is considered, maximization of inter class variance. The x is set of design variable.

$$x(k) \in [X_l(k), X_u(k)] \quad 1 \le k \le n \qquad (15)$$

$f(x)$ is a cost function or objective function depends on x values, and n indicates the length of variable set x. Where the $X_u(k)$ and $X_l(k)$ are upper and lower limits of design variables x(k). The Harmony search optimization algorithm parameters are (i) size of harmony memory(HM)
(ii) harmony-memory consideration rate (HMCR) (iii) pitch adjusting rate(PAR) (iv) distance bandwidth (BW), and number of iterations or improvisations(NI).
Second step is, configure the initial HM components (HMS Vectors). Let $xi = xi(1)\ to\ xi(\mathrm{n})$ randomly computed HM Vector: $xi(k) = X_l(k) + \left(X_u(k) - X_l(k)\right) * rand(0,1), 1 \le k \le n\ \ and\ i = 1, 2, \ldots, HMS,$ $that\ is\ length\ of\ HM$. Hence the lower and upper limits of possible search space are indicated by $X_l(k)$ and $X_u(k)$ respectively. Then in Harmony Memory (HM) matrix, each component is a harmony vector, there are HMS such vectors presents.

$$HM = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{HMS} \end{bmatrix} \qquad (16)$$

Finally third step, From HM matrix, a new x_{new}, new harmony vector is generated using threes operations , (i)memory consideration, (ii)random reinitialization (iii)pitch adjustment. Each newly generated x_{new}value scrutinized for where it is required pitch updating or not, for this purpose, pitch adjustment rate (PAR) is devised, which is composition of frequency and bandwidth factor(BF), these two factors to be adjusted to get new x_{new} value from local search space around from the harmony memory. The pitch adjusted new solution $x_{new}(k)$ can be calculated by $x_{new}(k) \pm rand(0,1) * BW$ with probability of PAR, this pitch adjustment is very similar to technique of mutation process in any evolutionary bio-inspired optimization algorithms. The range of pitch adjustment is limited by $[X_l(k), X_u(k)]$.

B. *Computation of Threshold level(Otsu's method)*

As per this technique for Multi-Level thresholding (MT), gray level[21]-[22] of image are portioned into classes or sets, for this process a thresholding (th) to be selected, the set of rules for bi-level thresholding is given below.

$$C1 \leftarrow p \quad if \quad 0 \le p < th,$$
$$C2 \leftarrow \quad if \quad th \le p < L-1 \qquad (17)$$

Where $C1$ and $C2$ are two classes, the pixel range $\{0, 1, 2, 3, \ldots\ldots, L-1\}$, $L-1$ is the maximum pixel vale, p is any gray value from given range. If the pixel value less then th then belongs to class $C1$, else it belongs to class $C2$.

$$\sigma^{2^c} = \sigma_1^c + \sigma_2^c \qquad (18)$$

Notice that for both (17) and (18), c value 1 if image gray scale image, where σ_1^c and σ_2^c in (18) are the variances of regions $C1$ and $C2$ are expressed as

$$\sigma_1^c = w_0^c(\mu_0^c + \mu_T^c)^2, \qquad \sigma_2^c = w_1^c(\mu_1^c + \mu_T^c)^2 \qquad (19)$$

Where the $\mu_T^c = w_0^c\mu_0^c + w_1^c\mu_1^c$ and $w_0^c + w_1^c = 1$. whereas $w_0(th)$ and $w_1(th)$ are the probabilities distributions for $C1$ and $C2$. Based on the values σ_1^c and σ_2^c, equation (20) presents the objective function:

$$J(th) = \max\left(\sigma^{2^c}(th)\right), 0 \le th \le L-1 \qquad (20)$$

From (19) $\sigma^{2^c}(th)$ is the variance of Otsu's [16] method for given th, evolution based optimization techniques used to

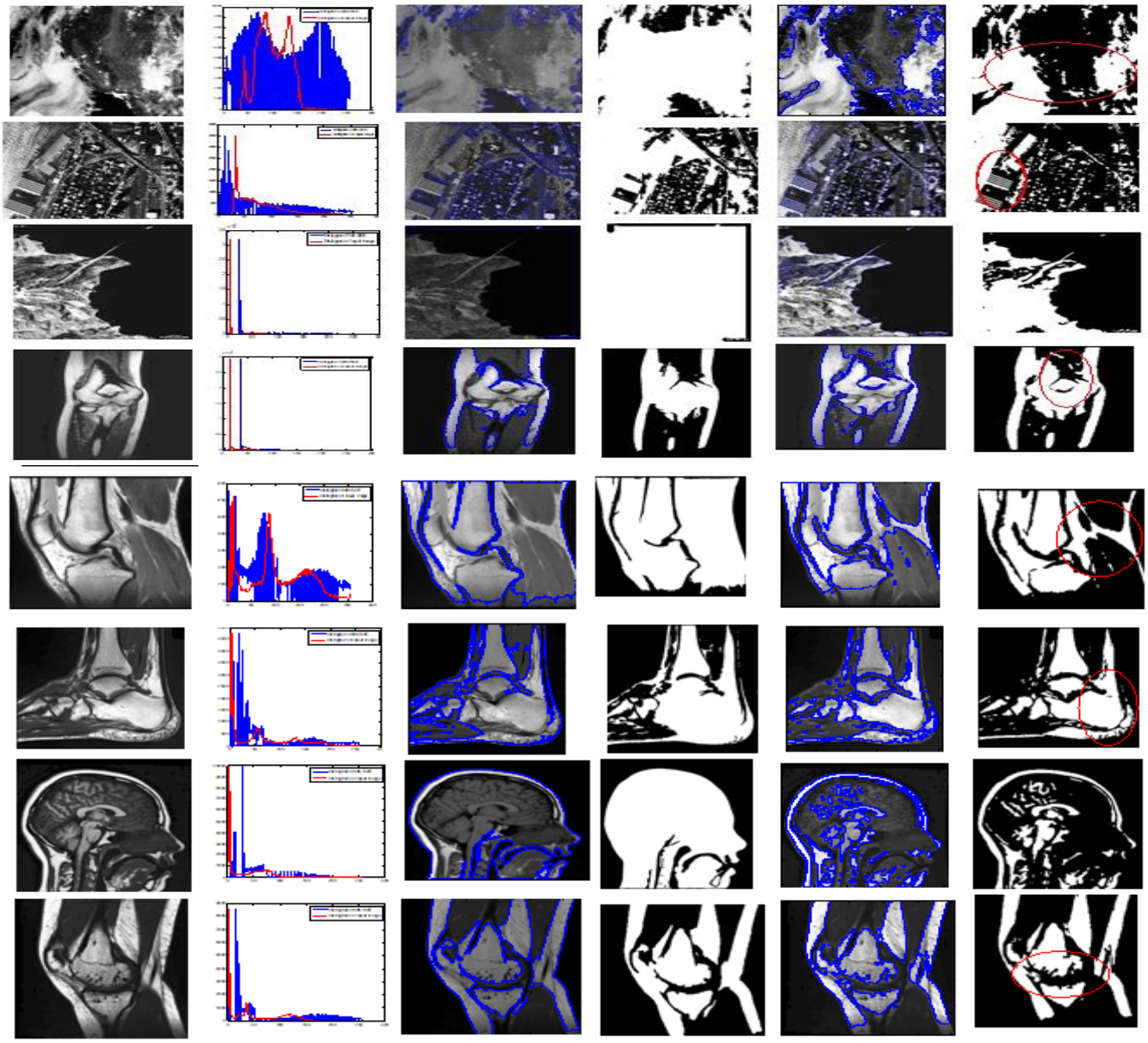


Fig.4. Column 1: Input Images, Column.2: Histograms of input image and segmented by Propose method, Column.3:Segmeted by SBGFRLS, Column.4: Binary version of column3, Column.5: Segmented by LSFBHEHS, Column.5: Binary version of column5

find intensity level (th) for maximizing objective function as given in (20).

C. *Implementation of Proposed Algorithm(LSFBHEHS)*

In this paper the multilevel segmentation is implemented on standard images by choosing the objective function or fitness function of Otsu's algorithm, different segmentation algorithms[17] can be devised by coupling HSA and Otsu's algorithm. The effectiveness of HSA is powerfully effected by values allotted to four parameters. Initially select each parameters randomly and execute algorithm, assign new values to algorithm parameters if the previous results are not acceptable, and execute the evaluating algorithm one more time. With final parameter values find the threshold value. After selecting the final optimized threshold, the histogram is divided into two parts by satisfying the cost function, then apply bi- histogram equalization on the considered image, finally apply SBGFRLS function for segmentation.

VII. ANALYSIS OF RESULTS

The main object of this research is focused on that the proposed technique is improved or efficient as compared to previous or existing methods specially for low contrast images, this research is basically application oriented type based on qualitative analysis.

Table- I: Dice Similarity Index and EME values

Name of Image	Dice Value with		EME Value with	
	SBGFRLS	*PROPOSED*	HE	BHE with HS Algorithm
Image.1	0.68	0.81	22.735	27.952
Image.2	0.84	0.98	23.520	54.183
Image.3	0.79	0.85	6.308	13.727
Image.4	0.78	0.85	3.544	12.802
Image.5	0.68	0.73	16.857	21.755
Image.6	0.81	0.92	23.482	28.842
Image.7	0.76	0.81	24.254	34.116
Image.8	0.89	0.95	15.629	21.382

For implementing our algorithm for images are considered named as Image.1 to Image.8. The MATLAB code developed for this paper is experimented on 8th generation Intel processor CORE i5-8250u, with clock speed of 1.60GHz with 8GB internal memory, the MATLAB version used for generation of results are R2013a. For comparative analysis between the results from two different algorithms (i) SBGFRLS and (ii) LSFBHEHS consider eight low contrast images taken from openly available source, threes images are satellite images and five images related to medical field. The images are depicted in Fig.3, Image.1 to Image.3 are satellite images and Image.4 to Image.5 are medical images mostly MRI images. Image.4 is a MRI scan of elbow it is consisting of mostly black pixel as in its corresponding histogram as given below that image. In image.5 is MRI of knee which is consisting of bone, soft tissue and mussels, the Image.6 is MRI of lower extremities(Leg) from this different bone part to be identified. From the Fig.7 the Image.7 is MRI scan of head cress section, finally Image.8 is MRI of Osteopoikilosis of knee bones, Osteopoikilosis is a sclerosing bony dysplasia characterized by multiple benign enostoses (bone islands). In Image.3 all the eight images along with corresponding histograms also portrayed. SBGFRLS method is one of the more efficient method for image segmentation for various applications, still few drawbacks are identified from this experimentation specially for low contrast images, it takes longer propagation time, and cannot propagate into all the areas of images with low contrast. This shortfall can be improved by LSFBHEHS, results are shown Table.1 and Fig.4 to Fig.6. Dice similarity index is a qualitative measure for comparing the segmented images, it should be high for better segmentation. In this experimentation three qualitative parameters are used for comparison of results (i) Time in seconds (ii) Dice Index (iii) EME. The Fig.5 illustrates the bar-charts for comparison of time(in seconds) for low algorithms SBGFRLS and proposed algorithm(LSFBHEHS) for Image.1 to Image.8, form this it very clear that proposed technique required less time as compare to SBGFRLS for segmentation.

The Table.1 illustrates the comparison qualitative metrics of Dice similarity index and EME[23]-[24], the second column in the table is name of images Image.1 to Image.8, from column 3 and 4 indicated that Dice similarity index values are high for proposed method as compared to the Dice values of SBGFRLS. From the same table we can observe that the EME values for image from Image.1 to Image.8 for comparing efficiency of image enhancement between two techniques namely HE and Bi-Histogram Equalization (BHE). The EME values are higher for BHE as compared to HE, to find optimized threshold level to slice the histogram in to two parts, Harmony Search Algorithm is used by maximizing the inter class variance.

From Fig.4, we can observe the resulting images for selected low contrast images, in Fig.4 the first column images are resulting of bi-histogram equalization on the corresponding images as shown in Fig.3. Then second column from Fig.4 is regards the histogram of input (low contrast) images and histograms of images which are enhanced by bi-histogram equalization based on Harmony Search Algorithm, it is very clear that the histograms of enhanced images are expanded as compared to histograms of input images, which is indicated in each images of second column, red colour plot is histogram of low contrast input image and blue colour plot is histogram of enhanced image. The column three from Fig.4 is segmented images by using SBGFRLS, number of iterations taken to run the level set function both the algorithms are 200 on each images, we clearly evidence that the active contour is unable to cover all the features by applying SBGFRLS on low contrast images, whereas by using LSFBHEHS algorithm can cover more features which are indicated in column five. From the sixth column of first row (Image.1) we can observe more details which are highlighted by a red colour ellipse as compared to details in fourth image from first row.

The fourth column of Fig.4 is binary version of the segmented by SBGFRLS, and the sixth column is similarly binary version of segmented image by proposed image, from these images as shown in column four and six, the white area indicates that the features or area covered by closed active contour as shown in previous columns, black area is outside the active contour as shown in Fig.2.

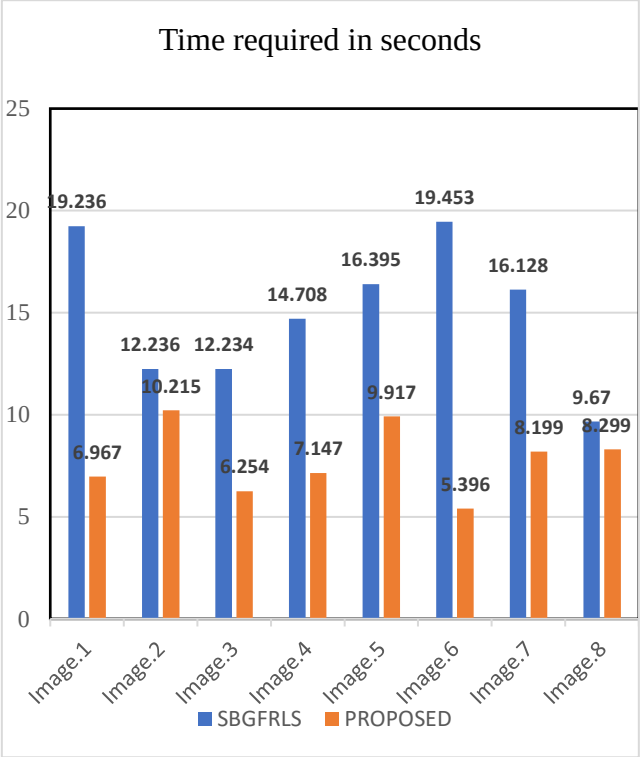


Fig.5. Time required for SBGFRLS and PROPOSED Algorithms in Seconds for eight Images

From second row of same figure mentioned above, image regarding a big city with different constructions, by comparing the fourth and sixth image of same row, the details (series of buildings) are emphasized by red circle, which are not appearing in fourth image for same 200 number of iterations with similar parameters.

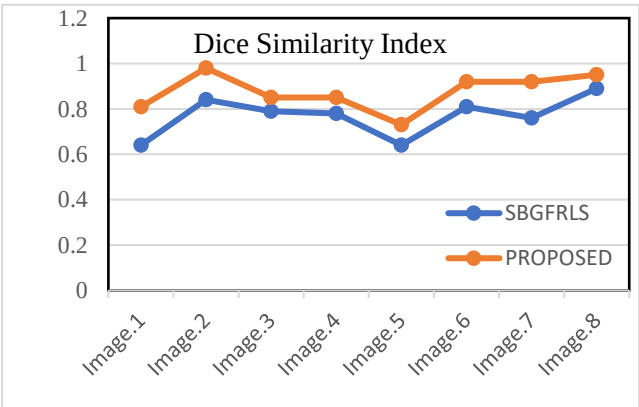


Fig.6. Dice Similarity Index for SBGFRLS and PROPOSED Algorithms for eight Images

The third row regarding a image of costal and part of sea (black area), by applying the algorithm SBGFRLS directly on the this image, the active contour is unable to propagate further, because the initial level unable to spread in the area where pixels with very frequency (or almost zero), difference between neighbouring pixels is very and the partial differentiation is minimal, which is as shown in forth image in third row of Fig.4, but once we observe the sixth image resulting from binarization of image segmentation by LSFBHEHS showing the various details which are not appearing in the third image. Consider the fourth row for Fig.4, compare the third images and sixth image, we can observe more bone internal bone details indicated by red closed line, which is result of proposed method.

The sixth row illustrate the image segmentation results of MRI scan of Lower Extremities (Leg) by using two algorithms, the sixth image is resulting of proposed technique show different details of bone parts as compared image resulting from SBGFRLS which is given in third image. In this same row the second image shows histograms of both methods, pixels ranging from 0 to 200 before enhancement, its range is widened up to 255 by BHE and segmentation with less amount of time and more details. The seventh image from Fig.4, before applying Harmony Search based BHE the gray level profile is spread up to 110(pixel value), but range expanded with enhancement, and results are very clear that, last image with more details, indicated with red colour closed line. In the last row from above figure, the image is MRI of Osteopoikilosis of knee bones, we can detect bone islands as shown in last image resulting from proposed image, which is clearly highlighted by red colour circle, the bone islands are not identified by segmenting the image directly by Level set.

VIII. CONCLUSIONS

Image Segmentation is very significant step in image processing for extracting various features in the image specially in medical and satellite low contrast images. For segmentation of low contrast images, the available level set based techniques in the literature cannot give better results because of inhomogeneity of gray levels, bi-histogram equalization based enhancement technique is applied on raw images, then apply SBGFRLS segmentation and convert into binary to identify objects. To find optimized threshold to portion the histogram Otsu's technique with HAS used. Results are cleared that proposed algorithm is more competent for low contrast images.

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AUTHORS PROFILE

Rangu Srikanth completed B.Tech in Electronics & Communication Engineering from JNTUCE, Kakinada, JNTU, Hyderabad, and M.Tech from JNTUH, Hyderabad, now pursuing Ph.D from Kakatiya University, Warangal in the field of Image Processing, research interests are Image Processing and Signal processing. Published many research articles in reputed internal journals and presented in International Conferences. Have life member of IE(I) and IETE. Presently working as Assistant Professor in Department of Electronics and Communication Engineering, Kakatiya Institute of Technology and Science, Warangal,

Dr. Kalagadda Bikshalu received Ph.D degree in Electronics & Communication Engineering from JNTUH, Hyderabad. He completed M. Tech degree in Digital Electronics & Communication Systems and. B.Tech in ECE from JNTU, Hyderabad. Presently he is working as Assistant Professor in Department of ECE, Kakatiya University College of Engineering and Technology (KUCET), Kakatiya University, Warangal, Telangana, India. He is active member of various professional bodies like IEEE, IETE and ISTE. His research interests are High K dielectrics, Signal and Image processing and Low power VLSI. He .have done several academic duties such as BOS Chairman for Departments ECE & EIE, Member of BOS, Departmental Committees member.