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Multimodal Integrated Technique for Wrist Fracture Identification

Manjula Gururaj Rao H , Nagaraja G.S

Abstract: ***Medical image processing is one of the fastest growing fields in Computer Science. It is a technique used to obtain the images of various parts of the body for clinical analysis to identify and treat diseases. Medical Imaging helps in detecting fractures, lesions present in the images like X-ray, CT-scan, and MRI. Fracture detections are difficult and sometimes may lead to the misjudgment. Existing fracture detection system is complex and accuracy of the detection is low. Hence, the proposed paper focuses on single and multi-modal system that helps radiologists in detecting the wrist fractures. The proposed system uses the multimodal system to detect the fracture in the wrist bone. It uses the combination of the Hierarchical centroid, Principal Component Analysis and Connected components analysis technique to identify the fracture in the wrist bones. This paper also elaborates on the various segmentation techniques used in the multimodal and single modal system.***

Keywords: Multimodal techniques, Watershed technique, Hierarchical Centroid, Connected Components, Principal Component Analysis, Frame Difference

I. INTRODUCTION

Image processing is a technique to perform some operations on images to extract desired information. It is a kind of signal processing in which image is given as the input and output maybe an image or features extracted from that image. Today, image-processing forms a core research discipline in engineering and computer science field too. It has following three stages.

- Image acquisition tools to import the images.
- Analysing and manipulating the images.
- Outcome is the image where the results altered or reported base on analysis.

Image processing can be classified two methods. Namely, analogue and digital image processing. Analogue image processing can uses for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing helps in the manipulation of the digital images using computers. Digital image processing has to go through three stages. They are pre-processing, enhancement and information extraction. In the year 1895, Wilhelm Roentgen discovered the X-ray technology.

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***** Correspondence Author
Manjula Gururaj Rao H*, Associate Professor, Department of Computer Networks & Management, RV College of Engineering, Bengaluru, India.
Dr G S Nagaraja, Professor and Associate Dean, Department of Computer Networks & Management, RV College of Engineering, Bengaluru, India.

Now it has improved lot and digital X-ray has discovered. X-rays are small wavelength, which passes through the human body, without damaging the objects present inside the body. The objects with the different densities result into different shadows on the X-ray image. Therefore, this results into the black-and-white images. This helps the doctors to go through the patient's body without damaging or performing surgery. The structure of the bone rendered with X-ray images, and if present, the fracture can detect. On special photographic films, X-rays are emerged using silver salts. In case of digital X-rays crystal, photodiodes are used. Crystal photodiodes are made by the materials are cadmium tungstate or bismuth germinate. This will help to capture the light as electrical signal pulses. Later the electric pulses are converts from the analog to digital signals. These digital signals are views in the computer. Digital X-rays are handy, environmentally friendly. Digital X-rays are less expensive compared to normal X-rays. Radiologist would look into the X-rays to determine the bone fracture. This is time consuming because the probability of the fractures in bone is low. Some fractures are difficult to spot, and can build the automated systems to support the doctors. This will assist the physicians and radiologists in their work and improve the accuracy of the results. Instead of spending the time by the doctor in identifying the fracture, the automatic system can sort the fracture and non-fractured y X-ray images with confidence. An algorithm used to perform an Automatic System. There is no particular algorithm can uses to locate the fracture in the human body's skeleton. The complexity of developing the algorithm is more due to the varying bone structures, body shapes; bone alignment, digital X-ray data interpretation, bone size and characteristics vary from person to person. Along with these extracting the contour information, bone orientation and bone segmentation and relevant features are very difficult [1, 3, 12, 15, 26]. Sometimes quality of the image produced by the X-ray is not good. Therefore, it has to process before analyzing it. The different pre-processing techniques can use to improve the quality of the images. Once the image has pre-processed then image has to undergo partitioning. This method called segmentation. After performing the segmentation, the results can uses for many purposes, such as detection of the fracture, malnutrition detections and osteoporosis.

II. SEGMENTATION

In computer vision, image segmentation is the procedure of partitioning a digital image into multiple segments (sets of pixels, also called as super-pixels). The objective of segmentation is to improve and additionally change the portrayal of a picture into something that is more significant and less demanding to break down.

Image segmentation is regularly uses to find objects and boundaries (lines, bends, and so on.) in images.

To be more precise, picture division is the way to dole out a mark on each pixel in a picture to such an extent that pixels with a similar name share certain attributes. Generally medical image segmentation methods could have classified into the following categories. They are as follows:

- Threshold
- Edge-based
- Region-based
- Classification-based
- Graph-based
- Deformable model [4,5].

A Threshold

Threshold is the most common and easy grey image segmentation method. This method is base for the threshold value to deviate a grey-scale image into a binary image. This is also an equitable histogram threshold. Given an image I, threshold method tries to find a threshold t such that pixels with intensity values greater than or equal to t are categorized into group 1, and the rest of the pixels I into group 2. Threshold requires that the intensity of the image have a bimodal distribution [1]. Uneven illumination is another factor that affects the performance of threshold. Adaptive threshold handles this problem by subdividing an image into multiple sub-images, and applying different thresholds on the sub-images. The problem with adaptive threshold is how to subdivide the image and how to estimate the threshold for each sub-image [5]. In general, threshold algorithms do not consider the spatial relationship between pixels. Moreover, the segmentation result is quite sensitive to noise. Threshold alone is seldom uses for segmentation of medical images. Rather it generally works as a part of image pre-processing, in the image-processing step [5].

B Edge-based

Edge based segmentation algorithms, are uses to detect and find the edges in the image. Sobel edge detector algorithm is uses 3X3 convolution kernels to compute the first order gradients along X and Y directions of the 2-D images.

Laplacian computes the second order derivatives of the image. Laplacian method is not uses directly on the images since it is sensitive to noise. It is combines with the Gaussian-smoothing kernel. This is known as Gaussian-smoothing kernel Laplacian. Laplacian of Gaussian (LoG) segmentation is uses in brain structures of 3-D MR images.

Canny edge detector [9] uses a double-threshold technique. A higher threshold t1 is uses to detect edges with strict criterion, and a lower threshold t2 is uses to generate a map that helps to link the edges detected in the former steps.

Edge-based image segmentation algorithms are sensitive to noise and tend to find edges that are irrelevant to the real boundary of the object. Moreover, the edges extracted by edge-based algorithms are disjoint and cannot completely represent the boundary of an object. Additional processing is required to connect them to form closed and connected object regions.

C Region-based

Typical region-based segmentation algorithms include region growing and watershed.

Region Growing: Region growing algorithm begins with selecting n seed pixels. The seed pixels are selected either manually or by certain automatic procedures.

The region-growing algorithm is applied recursively. The algorithm decomposes the n X n square images into four n X 1 square images. In the next step, the algorithm choses the one image with maximum intensity density. The above procedure will be recursively repeated, until a single point remains at the end. In the next step, the algorithm adds neighboring pixels, which has similar image features. This results into the region growing. The correct choice of homogeneity factor plays an important role in the success of the algorithm.

Region growing algorithms are fast compare to edge-based algorithms. If the images contain too much of noise, this algorithm may lead into the undesired segments. Region-based algorithms if applied to the in homogeneous region, results into the over-segmentation.

Watershed: Watershed algorithm is one of the region-based image segmentation algorithms. It works on the concept of mathematical morphology. Watershed algorithm divides the entire image and it is simple and spontaneous. Watershed algorithm performs the global segmentation. The result of the watershed algorithm has high accuracy and border closure. This can achieve by one-pixel wide, connected and closure of exact location of outline.

The concept of Watershed algorithm is flooding of the water in the landscape or topological relief. At each point, pixel's intensity is used to represent the height of the landscape. While performing the visualizing a grey scale image into its topographic representation, includes three major notions. They are minima, catchment basins and watershed lines.

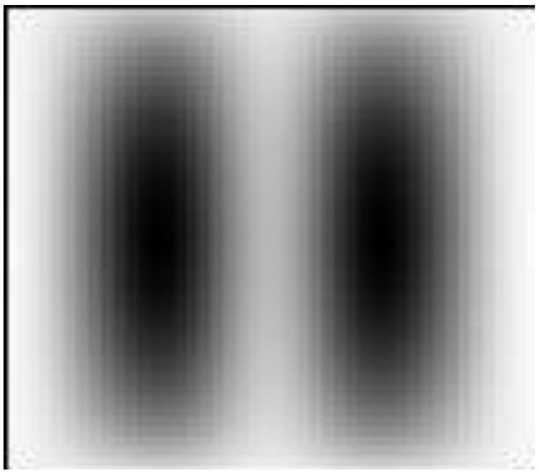


Figure 1: Watershed Algorithm Result

In the above Figure 1 shows the bright areas and dark areas. The bright areas have "high" altitudes and dark areas have "low" altitudes. The watershed result is showed as the topographic area in the Figure 2.

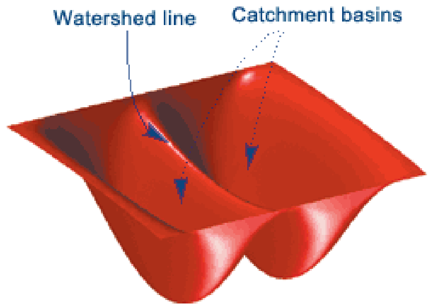


Figure 2: Topographic Surface of Watershed

In the above figure, leads to observe three types of points.

(1) The points present in different minima. These points yield different topological surface minima.

(2) The point represents, where water would fall into the single minimum. The gradient interior region is obtained using these points. This interior region is also termed as catchment basin.

(3) The point represents in which the water may fall into different minimum. These types of points are forms a crest lines. The crest lines are mainly used for dividing different catchment basins. These lines are called watershed lines. [1 and 12].

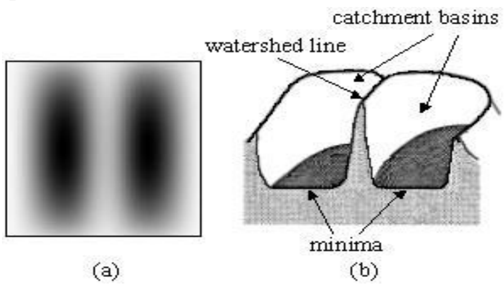


Figure 3: Grey Level Image and the Topographic Surface.

The input for the watershed algorithm is the gradient images. The watershed algorithm divides the lines of the catchment basins of rain falling over the regions (Figure 2). The catchment basin boundaries are located at high gradient points [14]. In watershed algorithm, intensity represents the basins having hole in its minima from where the water spills. When water reaches the border of basin, the adjacent basins will merges together. To maintain separation between basins dams are required and are the borders of region of segmentation. These dams are constructed using dilation. The watershed methods consider the gradient of image as topographic surface. The pixels having more gradient represented as boundaries, which are continuous [14, 15].

Before applying the watershed algorithm, the following approaches can be applied to get the better result of the watershed algorithm.

- Distance Transform Approach
- Gradient method
- Marker Controlled Approach

- **Distance Transform Approach**: In this approach distance from every pixel to the nearest nonzero valued pixel is calculated. The distance can be calculated using Euclidean distance, Chessboard distance transforms, city block distance transform [12].
- **Gradient Method:** The pre-process of the images are done using the gradient method and next watershed algorithm is applied on the image. Gradient method results into the image having high pixel values over the object edges and low pixel values other part of the image. This may produces the ridge edges in the outcome of watershed algorithm. This process may end with over segmentation.
- **Marker Controlled Method:** Marker is uses to represent the connected components apposite to an image. With the help of markers, gradient images modified. Markers can classify as internal marker and external marker.

Internals markers are uses for the objects and the external markers are uses for the boundaries [12]. Watershed algorithm can be constructed using two main approaches. They are:

- Watershed by flooding.
- Watershed by rain falling.

- **Watershed by Flooding:** Vincent and Soille suggest this approach. Holes impaled in all minimum. The water started flooding from the minimum of the lowest height to highest peak. Catchment basins will fill with the water gradually. When the different basins merge, the watershed will be build. The flooding of the water wills to stops when water reaches the maximum peak. Therefore, the watershed lines enclose the catchment basins.
- **Watershed by Rain Falling:** Bieniek and Moga suggested this approach. The approach mainly focussed on the connectivity components and process of rain. The basic idea is when rainwater falls; the water will be runs down along with the equivalent valley. The path in which the water flows is the connected components of the images and it is the steepest path between the basin and the fall. All the connected components, which are nearer, will form a one catchment basin. These catchment basins will be converts into the watershed lines [16].

Watershed algorithms are uses for global segmentations, border closure and high accuracy. It is uses to check the connected components of the images. Watershed algorithms work on 2-D images and 3-D images also. Using the watershed algorithm, this can get the exact locations of the images. Watershed algorithms can result into the over segmentation. Watershed algorithm is sensitive to the noise. Detecting the thin structures and low signal-to-noise ratio is difficult in watershed algorithm.

D Graph-based

Graph-based segmentation uses the concept of weighted graph. In this approach, the graph is forms using the vertex. This represents the each pixel of the image or region. Each vertex is also represents the similarity between pixels or regions.

A graph G = (V,E) can be partitioned into two disjoint sets A and B, where $A \cup B = V$ and $A \cap B = \emptyset$; by removing edges between them.

Graph-based algorithms try to minimize certain cost functions, such as a cut.

$$cut(A,B) = \sum_{U \in A, V \in B} w(u,v)$$

Where, w(u, v) is the edge weight between u and v. There are many algorithm is proposed on the minimum cut.

Graph-based segmentation algorithm tends to find the global optimal solutions. Graph–based algorithm is expensive due to the global optimum. Graph-based algorithm leads into over segmentation because it uses low-level features such as intensity and edges. This low-level information corrupted due to the noise.

E Classification-based

Classification-based segmentation algorithm is design uses the training. The parameters in the training sets use trial-and-error methods to obtain. The training set is purely subjective.

Depending on the selection of the training sample, the accuracy varies. The classification-based segmentation algorithm is more tiresome to use.

The some of the classification-based algorithms are classifies as the good segmentation and bad segmentation. Ren and Malik suggest this for the training of the classifier. This algorithm is uses to classify the criteria such as to find the similarities of brightness, texture; to get the contour energy and to find the curvilinear continuity etc. Another algorithm Human segmentation algorithm is uses to classify the natural images. The natural images are considered as the positive and negative as the randomly matching human images.

Fuzzy reasoning methods are also uses for the classification-based segmentation algorithms. In the fuzzy reasoning methods, the Laplacian-of-Gaussian is applied to obtain the zero-crossing area of the images. The high-level information can use to represent the linguistic forms. This can represent the different levels of the intensities such as dim, dark, medium, bright. Next step is to develop the fuzzy sets on the above information, as shown in the Figure 4. The fuzzy membership function is determines the range of intensity values, by using the fuzzy reasoning the rough boundaries is determined. The final boundary achieved by the search operation.

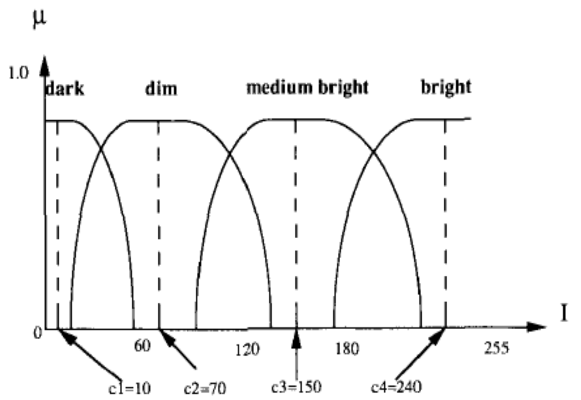


Figure 4: Fuzzy membership functions for linguistic descriptions dark, dim, medium-bright and bright

Toulson and Boyce propose the back propagation neural network in image segmentation. This algorithm is used to segment the manually samples, which is used to do the segmentation pixel by pixel. The inputs to this algorithm are class probabilities of the pixels with respect to the surroundings of the current pixel, which is been classified.

F Deformable Model

The deformable models training sets are uses first to recognize the shapes in the given image. The methods are statistical modeling [18]. Some of the deformable models are explains as below.

- **Active Contour Models (Snake contour models):** Kass et al proposed this algorithm. This is an iterative algorithm. This consists of two variables. That is external energy; this is calls as the image energy. External energy is mainly deals with the accuracy of the weighing edges of the image. The internal energy is the combination of two parts, i.e the bending of the curve edges and rigidity along the snake. Using the Euler's equation, the algorithm performs the job of minimizing the internal and external energies. The snake algorithm iteratively deforms and finds the minimum total energy, which will be the best fit of the object contour in the image [1, 18].

If the images have the sharp bending and the many curves, the performance of the algorithm is not good. Many methods are suggested to improve the performance of the algorithm; one of them is by using the global minimum. The initial guess is using the local minimum because, the performance may come to down, so instead of this global minimum is used to active the contour energy [18].

The snake algorithm forms the smooth contour for the region boundary. Due to this nature, it is good for edge detection, shape modeling, segmentation and motion tracking. The snake algorithm does not perform well on the concave regions in the image. The performance of the snake model is mainly depend on the initial configurations of the image (snake). Snake –based algorithm is not suitable to handle the images that are required for topological changes. Image intensity gradient is present in the narrow region of the convex part, which is located in the boundary of the object is the main image force. If the snake is present in the region without the image force, then it is impossible to pull towards the object boundary.

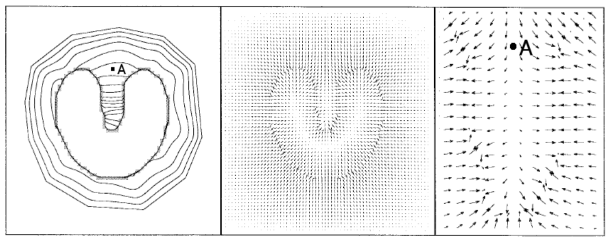


Figure 5: Gradient vector flow [Left: deformation of snake with GVF forces. Middle: GVF external forces. Right: close-up within the boundary concavity.]

Xu and Prince have proposed the Snake with Gradient Vector Flow (GVF) as shown in the Figure 5. This performs the image forces near the concave regions. This is uses to pull the snake towards the boundary of the object. The algorithm is less sensitive to the initial configuration of the contour.

Algorithm still is fascinated towards the undesired locations by noise. The following figures show the GAV algorithm results.

- **Level Set:** When the images are merged (as shown in the Figure 6), the snake algorithm is too expensive to perform, so Sethian proposed the level set algorithm. This algorithm has the level set functions, which is the higher dimensional surface.

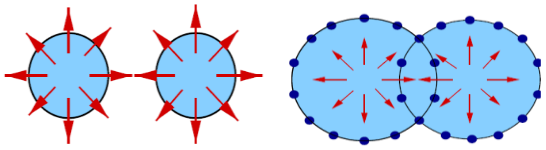


Figure 6: Merging of contours [31]. (a) Two initially separate contours. (b) Two contours are merged together.

The contour is obtains from the intersection of level set function and x-y plane. The equivalent boundary of the object has segmented. The level set function uses for 2-D and 3-D. In case of 2-D the level set function $z = \emptyset; (x, y, t)t = 0.$ But for 3-D t = is the highest distance from the point (x, y). Force F is uses as evolution of contour. The force F depends on some parameters such as global properties of the contour, local geometric information. After constructing the level set function, it is easy to develop the evolution of the interface. The level set functions are used to represent the possibly states. To construct at the initial it is very difficult, so the evolving zero level set constructed initially, then it is updates iteratively depending on the force F. The updating of the level set is done only to the values nearer to the current object boundary. The level set algorithm can be use the marching algorithm for the contour, if it propagates in only one direction. The level set function will be single function, even though after applying different operations on it. The level set algorithm cannot hold the shape information. The algorithm is very sensitive to noise.

- **Active Shape/Appearance Model:** If the objects have a definite shape then active shape model, (ASM) and the active appearance model (AAM), are used. The Cootes et al. propose these algorithms, this algorithm is applies when large a set of training samples are existing. The coordinates of the points in the shape represents the 2n-D vector$(x_1, y_1, x_2, y_2 \ldots x_n, y_n)$. The high dimensional (2n-D) space where the shape vector points are present is calls the Eigen space. ASM is calls as the Point Distribution Model (PDM). All the training samples form the cloud. It is calls as the Eigen space. To get the eigenvectors (known as the Eigen shapes) PCA (Principle Component Analysis) is used. By using the linear combination of the Eigen shapes and co-efficient any arbitrary shapes can be formed. Using the different co-efficient models can be deformed. If the AAM is used it will help to hold the information's like grey level, shape. Help in toughness of the ASM. The shape in the image can be deformed very easily and controllable manner than snake and level set algorithms. To build the point distribution in the high-dimensional Eigen space, several training samples are essential. If the Eigen shape is small, then the obtaining the preferred shape is difficult. In the other case, if the Eigen shape is too large, then to get the optimal solution may have high complexity.

G Atlas-based Segmentation Methods

In this model, the domain information of the structural and functional is considered. In atlas-based segmentation performs the manually segmenting and labeling of the n-dimensional images. Here image have the similar functional and structural parts. The main idea of atlas-based segmentation is first register the atlas; i.e atlas is assigns with the input image. Next step is to label the images with reference to the atlas. The atlas-based methods can constructs using the non-probability and probability methods. The probability may be for example voxels present in certain types of tissues or shapes present in the active shape models can consider. The Gaussian is uses for probability representations [1]. Atlas-based algorithms have two main steps they are global alignment and next local refinement.

- **Global Alignment:** In this stage, aligning of the position, rotating and scaling of the input images, according the atlas performed. Similarity transformation and affine transformation are usually used. In case of affine transformation, the highest degree of freedom (DOF) achieves. The affine transformation performs rotation, scaling, translation and shearing. The similarity transformation has only rotation, scaling, translation. The similarity and affine transformation are linear transformations, because of which the computational complexity has very low. To have more variations of the atlas, the non-linear transformation is considered. Because of which the global alignment can be more accurate. The computational complexity of the non-linear transformation is also very low in this case of segmentation methods. The rigid transformation not considered, because it uses only two types of transformations, i.e, rotation and translation. The transformation using automatically or manually performed.
  - **Local Refinement:** The main job of the local refinement is to align the target and the atlas as accurately as possible. The accuracy is the main intension; because of this, the methods had more concentrate on the more details of the target and the atlas images. This makes the algorithms more complex. The local refinement has two main approaches; they are local deformation and pixel classification.
  - **Local Deformation:** In this, approach the deformation of the image done locally and made fit accurately with the target image. There were number of methods present to perform the local deformation. Some achieved searching method and some achieves by guessing the corresponding points in the target image.
  - **Pixel Classification:** This type of approach performed in the probabilistic atlas-based segmentation. Pixel classification divides the pixels into several groups, these groups divided according to the anatomical parts. The main idea of the classification of the pixels are done, according to the maximizing a posterior probability of the pixels,

which is present in the particular anatomical part. The classifications of the pixels done according to the features used in pixel and pixels position information.

III. HIERARCHICAL CENTROID

To find the centroid of an object is the arithmetic mean position of the all the points present in the figure. To find the centroid of the n-dimensional space is the mean positions of all the coordinate points in all directions. In case of the hierarchical centroid, the hierarchical descriptor is uses to divide the images. X-mean value is uses to find the centroid of each divided image parts. This process repeats for all divided image parts. The process stops once the depth or the number of the levels or the hierarchy is reaches. The final difference achieved to get the centroid of the image.

IV. PERIPHERAL COMPONENT ANALYSIS (PCA)

Principal Component Analysis is uses to reduce the dimensionality of the images. PCA shrinks the information. PCA can define mathematically as a linear orthogonal transformation. This transforms the data into a new coordinate system. During the transformation of the data, the greatest variance will be projects to the first coordinate. The first coordinate calls the principal component. The next greatest variance transforms to the second coordinate and so on. When the transformation is applied, the linear correlated variables transforms into the non- correlated variables. This proves that there is a redundancy of the information. If the redundancy removed, then compression of the information achieved easily. PCA uses the translation and rotation on the original axes to transfer the variance of the second variable onto the first variable; as the result, the data will project into the new axes. The eigenvalues and eigenvectors determine the direction of the projection. Principal components are the first few transformed information features. Principal components are rich in the information, whereas the last components are mostly unwanted, redundant and noisy information. During the transformation of the information only the first few information will be retained, allows us to compress the data, by leaving the last information.

V. CONNECTED COMPONENT ANALYSIS

A group of the pixels are connected to each other are called the connected components of the image. The identifying and labeling is the first step in the process of fracture identification.

VI. PROPOSED SYSTEM- MULTIMODAL ANALYSIS

The fracture can be detected using the single model. However, the result is not very good. Therefore, the multimodal system is proposed. The proposed system detects the fracture by using the frame difference and data analytic techniques. In this section, frame difference model, for the identification of the wrist fractures are discussed, the results shown with the help of figures.

Proposed System architecture of the Multimodal System: The Figure 7 shows proposed model design for the frame difference. Here the frames of the images in each models are compared.

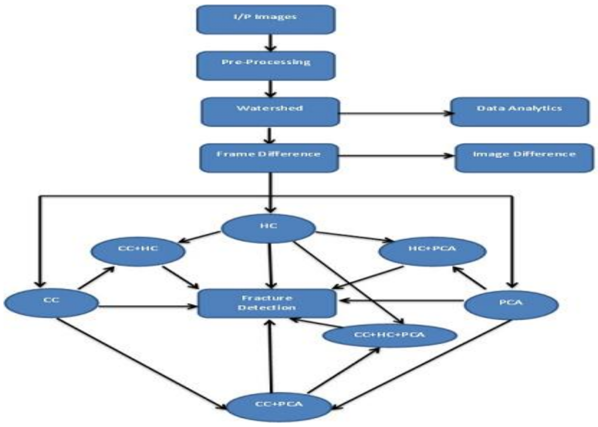


Figure 7: Proposed Architecture of the Multimodal System.

The proposed model contains the following combinations:

- Watershed and the Image difference
- Watershed and the connected component
- Watershed and the hierarchical centroid
- Watershed and the principal component analysis
- Watershed + connected component + hierarchical centroid
- Watershed + connected component + PCA
- Watershed + connected component + hierarchical centroid + PCA

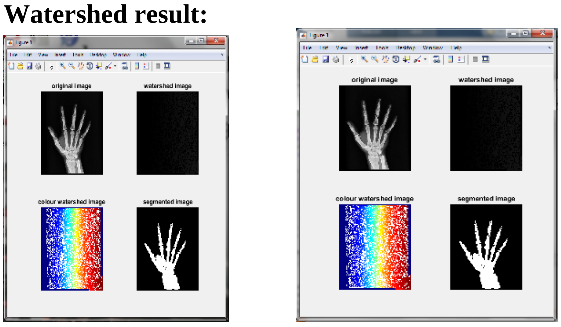
A. Watershed algorithm and image difference implementation

Algorithm:

Step 1: input the pre-processed image.
Step 2: Convert the image into the grey scale image.
Step 3: Apply watershed to the above image.
Step 4: Convert the watershed image into the coloured image.
Step 5: Convert the image into the non-flat structure.
Step 6: Convert the image into the binary image.
Step 7: Apply the steps 1 to 6 for original and fractured image.
Step 8: Find the difference between the images.
Step 9: Represent the histogram of the images.

After executing all the steps, the following results achieved.

Watershed result:



a b

Figure 8: Watershed Output (a) Original Image (b) Fractured Image.

In the above figure, the watershed coloured output obtained. We can observe that the watershed monochrome images will result clearer picture of the fractured image.

Image difference: In image differences, we find the pixel difference of the two images. The two images have the difference, but the values are very less. Therefore, we represent the histogram of the difference image.

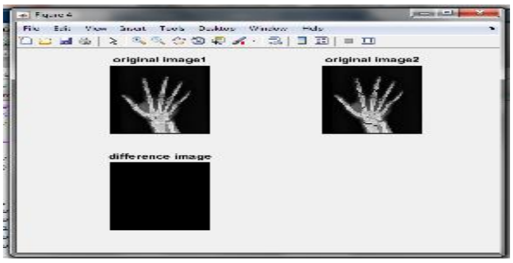


Figure 9 (a): Image differences of the Original and Fractured Image.

The observation is made from the above that, if the difference is large it can be seen easily, and if is very small, it is very difficult to analyse. For this reason, the multimodal system is proposed.

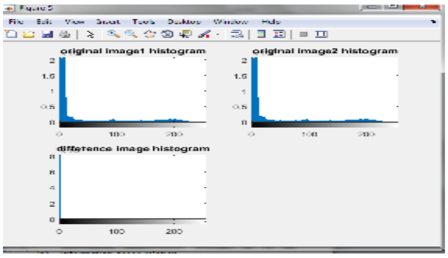


Figure 9 (b): Histogram of the Original & Fractured Image and Image Difference

B. Watershed and Hierarchical centroid

First, the image description obtained. Next, compute the x-coordinate of the centre of the mass. Then the descriptor then subdivides an image into two images by the x-coordinate and calls recursively on altered of each of the two sub-images. The equalized values are calculated. The values are relative to the complete image. Next calculated values are returns. In order to equivalence the representation, the descriptor is calculated. The descriptor value is the transposed image and the two resulting vectors are concatenated. When hierarchical source code is executes, it will give two types of the results. One is zero and other one is any value. The result is zero implies that the images are same and no fracture is detected. Otherwise, the images are slightly different and fracture detect.

Algorithm:

Step 1: Input the output of watershed images. That is original and fractured images.
Step 2: Calculate the image descriptor.
Step 3: calculate the hierarchical centroid of image1
Step 4: calculate the hierarchical centroid of image2
Step 5: Find the difference between the centroids.
Result: shows the distance between alef1 and alef2: 0.00048866.

The observation is made that the original and fractured images. Here the centroid of each images are calculated. The difference between the centroid of the images are obtains. This algorithm is better than the watershed and image difference.

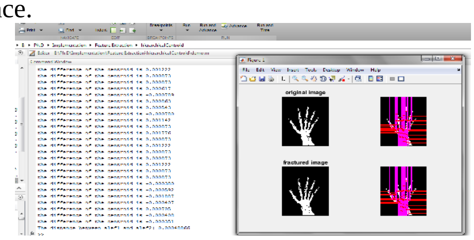


Figure 10: Hierarchical centroid of Original and Fractured Image

C.Watershed and connected Component

In this model, the images scan done. i.e pixel-by-pixel from left side to right and top to bottom. The pixels are analysed to check the connected component. The analysis is obtains by the intensity. i.,e the pixels which are adjacent will share the same intensity. After checking the all the pixels, in a grey-scaled image, leads into the different types of connectivity. The nearer connectivity types grouped together and labelled respectively.

Algorithm:

Step 1: Input the watershed bmp fractured or the original image.
Step 2: Apply the filtering on the image.
Step 3: Apply edge detection on the images.
Step 4: Resize the image. Smooth the image to get the better result.
Step 5: calculate the connected component of the image.
Step 6: Store the extracted connected component image.

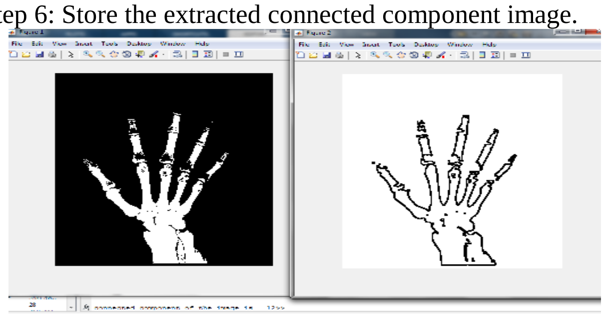


Figure 11 (a): Connected component (CC) of the original image with CC-17.

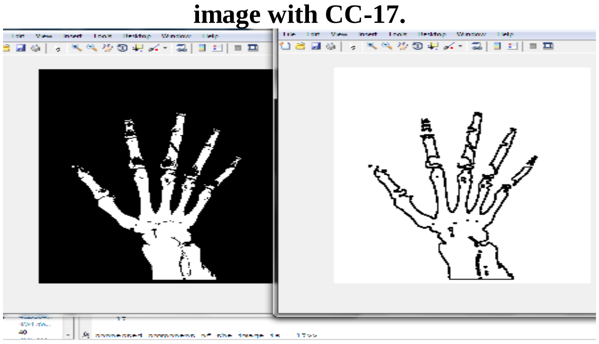


Figure 11 (b): Connected component of the fractured image with CC as 12.

In the above Figures 11 a and b, connected component analysis method, the observation carried out, i.e as the number of fractures is more the connected components of the image decreases.

Watershed connected components and hierarchical centroid

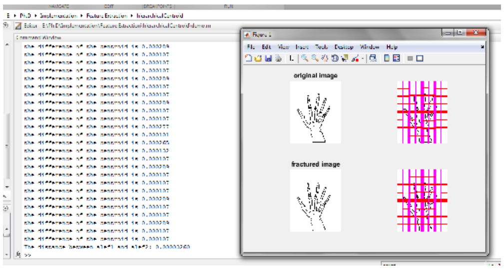


Figure 12: Hierarchical centroid of the original CC t image and the fractured image

Result: Shows the distance between alef1 and alef2: 0.00003260. The results obtained from the combination of the connected component analysis and the hierarchical centroid. The output image of the connected component analysis forwarded as the input to the hierarchical centroid to calculate the centroids of the fractured and non-fractured images.
The difference is calculated. If the image has the difference zero implies that no fracture. Otherwise, fracture is present.

D. Principal Component Analysis

Principal component analysis (PCA) is uses the orthogonal transformation of the pixels along the principal axis.

Algorithm:

Step 1: Read input image, store as the image matrix.
Step 2: Generate the dataset.
Step 3: Finding a mean and subtract the values in the image matrix.
Step 4: find the covariance of the matrix.
Step 5: Find the eigenvectors.
Step 6: Driving the new dataset and find the projection onto the eigenvector.
Step 7: find the final classification.

The output of the watershed with PCA is not good. It is difficult to measure. So, the different models are designed.

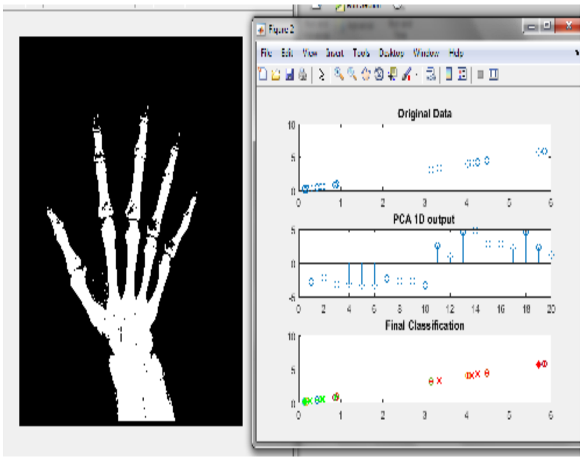


Figure 13 (a) PCA of the original image

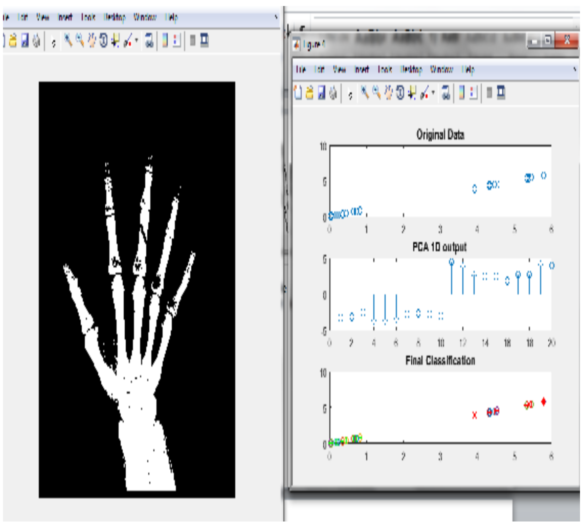


Figure 12 (b) PCA of the fractured Image

The above Figure 12 (a) and (b) shows the PCA of the fracture and non-fractured image. By observing the pixels scatter in the image we can detect, fracture is present or not. The result is not very clear.

E. Watershed connected component and PCA

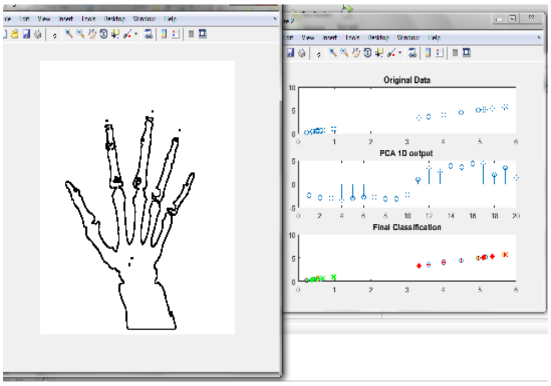


Figure 13 (a) PCA of the connected component of original image

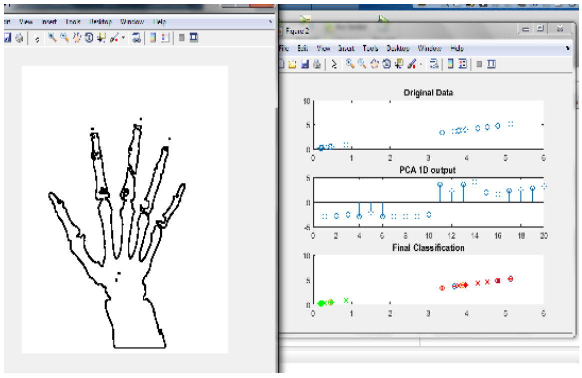


Figure 13 (b) shows the PCA of the connected component of fractured image

- **Watershed connected component PCA and hierarchical centroid**

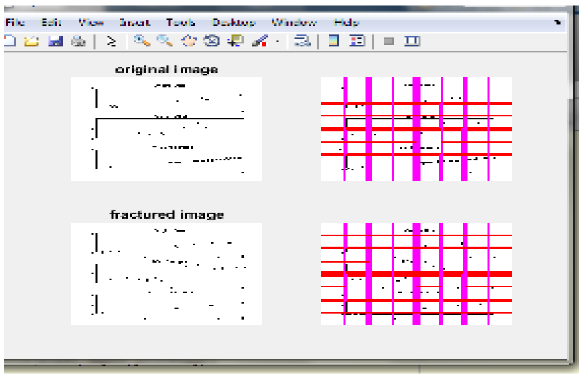


Figure 14 shows the PCA and hierarchical centroid of the original image and fractured image

Result: The distance between alef1 and alef2: 0.00013848

F. Comparison of all the Multimodal Systems

- Algorithms are applied to the detection of fracture using single modal and multimodal
- Results are studied.
  Following conclusions made according to the Frame difference. The above result applied on the 770 fractured images and the original image. Fracture detection done using frame difference and the image visualization.

Fracture detection checked using analytical methods and graph differences.

Table 1: Result of different types of the algorithm and the combination of the algorithms.

ANLYSIS OF THE ALGORITHM								
SL.NO	ALGORITHM NAME	FRR	ERR	EXPECTED ACCUARCY	ACCURACY =(TP+NP)/(TP+NP+FN+FP)	PRECISSION=TP/(TP+FP)	SENSITIVITY=TP/(TP+FN)	SPECIFICITY= TN/(TN+FP)
1	WS_PCA	49.2	24.6	75.4	83.33	100.00	72.57	100.00
2	WS_CC_PCA+FIG	47.8	23.9	76.1	81.92	100.00	68.49	100.00
3	WS_CC_PCA-4	47.8	23.9	76.1	79.76	100.00	67.38	100.00
4	WS_CC_PCA-8	49.2	24.6	75.4	81.92	100.00	68.49	100.00
5	WS_HC	0.00	0.00	100.00	100.00	100.00	100.00	100.00
6	WS_CC_HC	0.00	0.00	100.00	100.00	100.00	100.00	100.00
7	WS_CC_PCA_HC	0.00	0.00	100.00	100.00	100.00	100.00	100.00
8	BLOB_MEAN	2	1	99	99.05	100.00	98.18	100.00
9	BLOB_INTENSITY	0.5	0.25	99.8	99.76	100.00	99.55	100.00
10	BLOB_AREA	45.5	22.75	77.3	84.76	100.00	77.05	100.00
11	BLOB_PARAMETER	14	7	93	94.23	100.00	90.00	100.00
12	BLOB_CENTROID	3	1.5	98.5	98.59	100.00	97.35	100.00

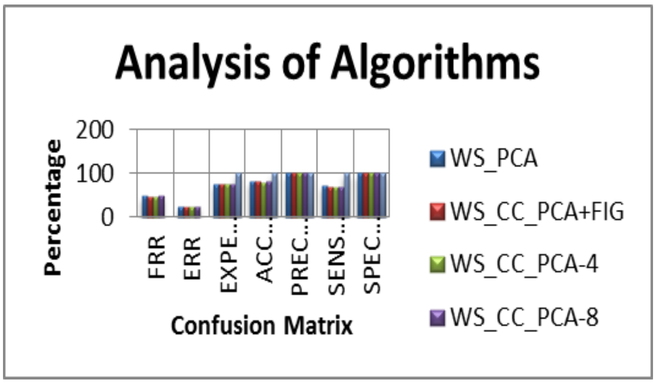


Figure 15: PCA and hierarchical centroid of the original image and fractured image

The above figure shows the percentage of the confusion matrix, which has the values such as sensitivity, specificity, precision and accuracy. The above graph shows that the watershed and connected component + PCA and the hierarchy is the best. In addition, shows that the hierarchical method is the best.

VII. CONCLUSION

Detection of the wrist fracture using the existing system is difficult and accuracy is not very good. Hence, the proposed system elaborates on different types of segmentation techniques along with different types of feature extraction methods and algorithms and its result. The results are compared with the single modal and the multimodal system. The results show that the hierarchical centroid method is the best method for the detection of the fracture in the wrist. This method can be combined with the other methods. The multimodal system is also yields the better result in case of the hierarchical centroid combination. Fracture identification is done using the frame difference technique and results are checked with the confusion matrix.

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AUTHORS PROFILE

Manjula Gururaj Rao H, currently pursuing Ph.D in the field of medical image processing at Jain University under the guidance of Dr. Nagaraja G S. I did my M. Tech from Allahabad Deemed University, Naini Allahabad, and B.E from NMAMIT, Nitte. I have more than 4 publications in reputed international journals and possess around 17 years of teaching experience. I worked as Assistant Professor, Associate Professor and also as a HOD in the earlier organizations.

Dr G S Nagaraja, is currently the Professor and Associate Dean in RV College of Engineering, Bengaluru. He specialises in Computer Networks & Management, Multimedia Communications. IEEE-CS Execom member of IEEE Bangalore Chapter, IEEE Senior Member, IEEE Journal reviewer. He is also Active member/reviewer of IEEE, ISTE, CSI and RVCE-CISCO academy and involved in many activities under these.