

Bone Cancer Detection from X-Ray and MRI Images through Image Segmentation Techniques

Abhilash Shukla, Atul Patel

Abstract:: This paper is based on integration of the biomedical field and computer science. Paper contains the study of bone cancer and features to predict the type of the same. Related work to find cancer in human body using computer vision is discussed in this paper. Image segmentation technique like sobel, prewitt, canny, K-means and Region Growing are described in this paper which can be stimulated for X-Ray and MRI image interpretation. Paper also shows the result of edge based and region based image segmentation techniques applied on X-Ray image to detect osteosarcoma cancer present on bone using MATLAB. Finally, paper concluded by finding best suited segmentation method for grey scaled image with future aspects.

Keyword: Cancer, bone cancer, osteosarcoma, Ewing, image segmentation, edge based segmentation, region based segmentation

I. INTRODUCTION:

Image segmentation is a way to process and acquire hidden aspects within the image. To achieve this, image is segmented into several sub parts of the same image. These techniques are useful in image compression, object recognition, boundary line detection of the given object and many similar applications where the prime objective is to develop computerized vision applications. Image segmentation simplifies the image by assigning label to group of pixel which having similar characteristics and features[1]. As the given image is portioned into the chunks of the images, each chunk must be a group of pixels of similar characteristics so as they can be categorized with specific label or category.

Abnormal growth of cell which likely to attack and spread into any organ of human body consider as cancer. According to the survey of National Institute of Cancer Prevention and research (NICPR) in India, around 2.5 million people living with the disease. Over 7 lakhs new cancer patients registered and 556,400 deaths because of cancer registered every year. International Agency for Research on Cancer (IARC) predicted 21.7 million cases and 13 million deaths related to cancer worldwide in year 2030. There are 75 types of cancer exists and one of them is bone cancer in which osteosarcoma and Ewing tumors is common. Death rate can be reduced by detecting and diagnose type and stage of cancer in its early stage and by starting right treatment.

An x-ray also called radiograph is a noninvasive medical test in which it shows inner part of body using radiation so that radiologist can diagnose.

Magnetic Resonance Imaging show same thing in more detail using powerful magnets and radio waves. In both techniques, result is generated into gray scaled image. Image segmentation techniques can be applied on Bone X-Ray or MRI image to recognize an unwanted growth of bone which may be Benign (not cancer) or Malignant (cancer). By the size, shape and other features, bone cancer type can also be decided.

So, the point here is to collaborate these two different aspects of technology i.e. image segmentation and x-ray or MRI to get rid of a very serious medical condition i.e. cancer. In this paper, we have tried to analyze various image segmentation techniques on x-ray or MRI reports to study the abnormal growth of the bone. The article demonstrates various image segmentation techniques and proposes best suitable technique under various circumstances.

II. APPLICATION AREAS OF IMAGE SEGMENTATION TECHNIQUE IN CONTEXT OF MEDICAL SCIENCE

Image segmentation is the most vital activity or process in the area of image analysis. In the process of image segmentation, the image is partitioned into meaningful chunks so as each chunk is different than others and each one of them is meaningful. This image segmentation technique is used frequently in the field of medical science where images of X-ray, CT Scan, MRI, etc are segmented and it will be used to classify or determined or diagnose the disease. In the field of medical science, such images are segmented from the organ like heart, brain, lungs, liver, etc. are segmented to check their abnormal growth or infection. Such image segmentation techniques are used to distinguish pathological tissue, such as tumor from normal tissue and so as this will have determined the way of treatment and medicine plan for the patient.

In most simple case of image segmentation especially in the field of medical science, the image is first segmented into two primary classes that is foreground image and background image. These images are being segmented with the help of attribute selection. Basic attributes are identified and based on these characteristics, images are being divided into small chunks of images. Segmentation is required to isolate the object from whole image on which analysis can be applied to identify the presence and type of tumor. The process of analysis and enhancement of X-Ray, MRI and ultrasound considered as biomedical image procession. Now days there are several software available with algorithm by which process can be automated and also give accurate results.

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AsmaYasrib and Mohd Adam Suhaimin shown several applications of image processing in medical field[11].

III. LITERATURE SURVEY

Kishor Kumar Reddy C, Anisha P R and Narasimha Prasad L V proposed an algorithm to calculate mean intensity and stage of cancer based on tumor size [2].

Kishor Kumar Reddy C, Anisha P R and Raju G V S given a Novel Approach for Detecting the Tumor Size and Bone CancerStage using Region Growing Algorithm[3].

Dipali M. Joshi, Dr.N. K. Rana and V. M. Misra developed Neuro Fuzzy Classifier to recognize different types of brain cancers[4].

MaryamsadatAmini, Peng Liu, Scott E Umbaugh, Dominic J. Marino and Catherine A. Loughinsuggested to use The Computer Vision and Image Processing-FeatureExtraction and Pattern Classification (CVIP-FEPC) software to apply Thermographic Image Analysis Method in Detection of Canine Bone Cancer [5].

Miss Hemangi S. Phalak and Mr. O. K. Firkeproposed a pre-processing methodology to enhance the MRI image and combination of both modified texture based region growing and cellular automata edge detection for detection of brain tumor[6].

MadhuriAvula, Narasimha Prasad Lakkakula and Murali Prasad Raja use k-mean clustering algorithm, calculate sum of pixel intensities for extracted tumor part and compute mean intensity to detect bone cancer[7].

Rahul kansal, Puneetgupta, Manjit Arora, Priyanka Mattoo, ArtiKhurana, InduBhasin discuss a case report to differentiate Osteosarcoma or Ewing's sarcoma[8].

Muhammed Anshad PY and S.S.KUMAR discussed recent methods for the detection of tumor using Computer Aided Diagnosis with its advantages, disadvantages and accuracy[9].

S. Vitulano, C.DiRuberto and M. Nappi (1997) describe three techniques for biomedical image segmentation based on Entropy, Fuzzy Entropy and the Least Square Method [10].

IV. FEATURES FOR IDENTIFICATION OF BONE CANCER TYPE

Tumour can be classified in benign and malignant also known as neoplasm. Benign is just abnormal growth of cell in human body and it is not a cancer whereas malignant is something in general called cancer. According to American cancer society there are 75 types of different cancer exists. Bone cancer is one from them in which thin layer is formed around the infected bone. Further the bone cancer is further categorized in 19 different types (refer figure 1) from which Osteosarcoma and Ewing tumour are common.

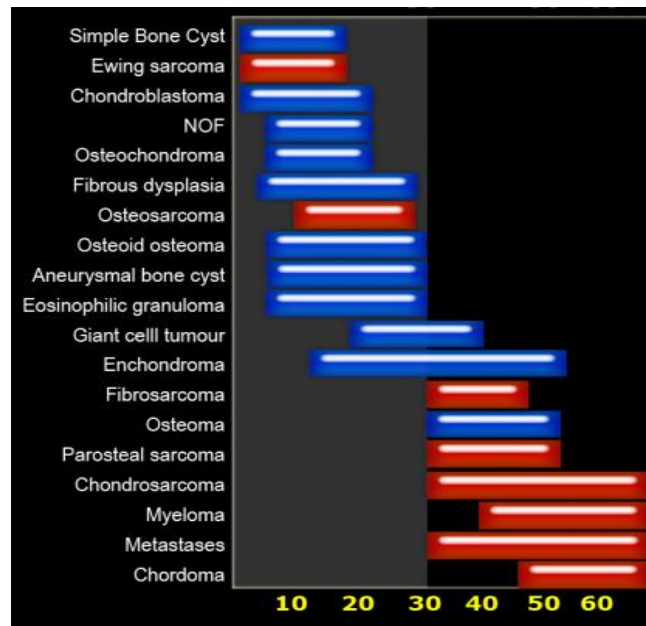


Figure 1 Possibility of Bone cancer at different age

All these cancers have different characteristic and have a possibility at different age (refer figure 2). Possibility of Osteosarcoma is between age of 10 to 30 of human and Ewing can be to the child normally under 20 years.

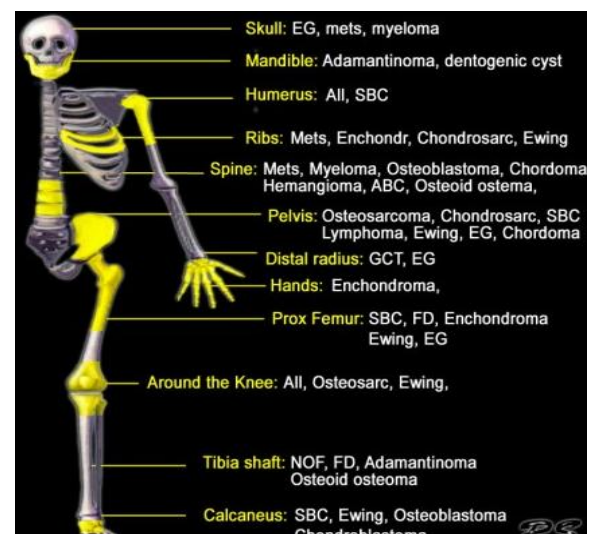


Figure 2 Possibility of bone cancer at difference location of body

Position in human body where bone cancer appears helps in diagnosing the type of the particular cancer (refer figure 3). Second, the position on bone gives clear idea about type of bone cancer. In medical, bone can be divided into three parts Epiphysis, MetaPhysis and Diaphysis (refer figure 3) to understand the structure of bone. Epiphysis is joint point in bone, Diaphysis is middle part of bone and Metaphysis join Diaphysis and Epiphysis. Osteosarcoma can be on metaphysis part of bone and ewing tumor can be on diaphysis.

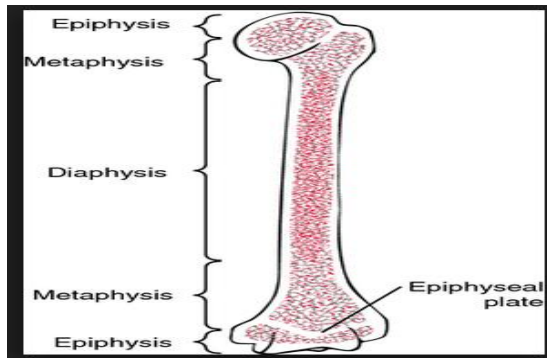


Figure 3 Structure of bone

Figure 4 shows all 19 types of bone cancer based on various parameters like age, position on bone and appearance of it. Appearance of Osteosarcoma is round shape with rough edge and Ewing has eclipses shape having less opacity.

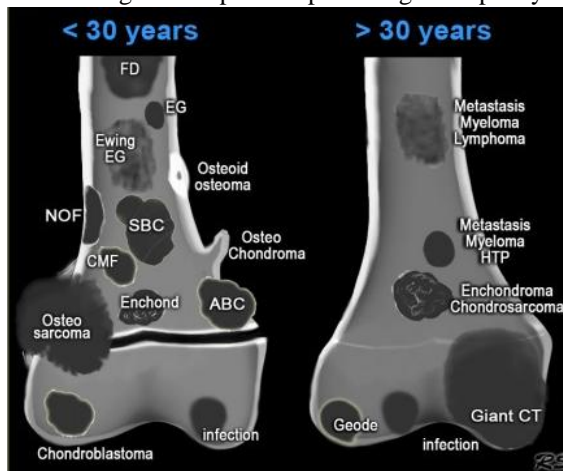


Figure 4 Appearance of bone cancer

Table 1 Features list to identify type of bone cancer

Feature	Values
Age	<30 and >30
Body Part	Mandible, Humerus, Ribs, Spine, Pelvis, Distal Radius, Hand, Prox femur, Knee, Tabia shaft, Calcaneus
Bone Part	Epiphysis, Metaphysis and diaphysis
Appearance	
Shape	Round (small, medium and big)
Edge	Smooth, rough and white color edge
Texture	White and black dots
Soft Tissue	Present, Not Present

V. OVERVIEW OF AVAILABLE IMAGE SEGMENTATION TECHNIQUES - TO DETECT BONE CANCER

Image segmentation techniques categorized into two main parts.

1. Layer Based Segmentation
2. Block Based Segmentation

As we are interested in object detection, we focus only on block based segmentation techniques.

In Block based segmentation also there are two type of segmentation technique.

1. Edge Based Segmentation

2. Region Based Segmentation

Sobel, Prewitt and Canny techniques from edge based and K-means and Region growing techniques from region based have been discussed with the result on X-Ray image in upcoming section.

A. Sobel edge detector

Sobel edge detector identifies the edges in an image by the operator of 3 x 3 convolution kernels. Second kernel obtains by the rotation of 90 degree of first kernel.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Kernel Gx help in identify vertical edges and kernel Gy identify horizontal edges. The kernels can be use individually to the input image, to generate separate dimensions of the gradient component in each direction. To find absolute magnitude of gradient is:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

An approximate magnitude computed using:

$$|G| = |Gx| + |Gy|$$

It is much faster to compute.

spatial gradient is:

$$\theta = \arctan(Gy/Gx)$$

Here consider, orientation 0 is consider to mean that the direction of highest difference from black to white runs from left to right on the image, and other angles are calculated anti-clockwise from this.

B. Prewitt Edge Detection

Like sobel, prewitt is also use for edge detection from image. Prewitt operations have two masks to detect edge in horizontal and vertical direction.

$$Vertical\ Mask \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$Horizontal\ Mask \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

Above two matrices give vertical edges and horizontal edges. Here first order derivate is calculated and differences of pixel intensities of edge region is further calculated. Remaining steps are same as sobel edge detection technique.

C. Canny Edge Detection

Canny Edge detection algorithm designed by John F. Canny in 1986 for optimal edge detection.



It shows the position of tracked intensity discontinuities in grey scale image. There are four steps to detect edges in image using canny operator.

Step 1: Gaussian filter is used to remove noise for the original image. The Gaussian smoothing can be performed after the suitable mask has been calculated.

For example Gaussian kernel of size 5

$$K = \frac{1}{159} \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

Step 2: Use Sobel kernel to get derivative in horizontal (G_x) and vertical direction (G_y) discussed in Sobel Edge detection.

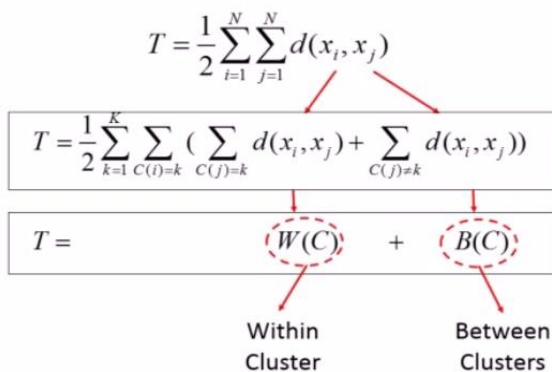
Step 3: Remove pixels that are not edges which result a binary image having thin edges. Then trace along the edge in the edge direction and set pixel value to 0 so that it not considers as edge. This process knows as non-maximum suppression.

Step 4: Use two thresholds upper and lower. The pixel considers being part of edge if pixel gradient is higher than the upper thresholds. The pixel not considers being part of edge if pixel gradient is below than the lower thresholds. In a case where pixel gradient is between the two thresholds and if it is connected to pixel which is above the upper threshold then it is accepted as a part of edge.

D. K-means Clustering

K-means clustering algorithm was developed by J. Macqueen in 1967. I 1975 it was again redesign by J.A.Hartigan and M.A.Wong. K-means clustering algorithm grouping objects based on features into K number of groups. Grouping is the way of classifying the data. This grouping is done by minimising the sum of square of distance between which can be data or pixel in image and the corresponding cluster centroid.

K-Means: Within and Between Cluster



E. Region Growing Algorithm

Region growing algorithm is also classified as pixel based image segmentation because seed point is selected initially. Then surrounding pixels of initial seed point are examined and determines whether particular pixel should be part of region or not. In this way an image partitions into regions.

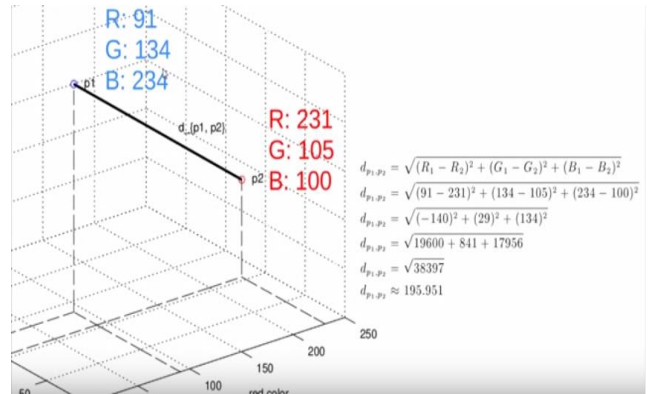


Figure 5 Euclidean distances to measure pixel homogeneity

Criteria for selection of pixel

$$d_{p_1, p_2} \leq T \rightarrow \text{pixels are homogeneous}$$

$$d_{p_1, p_2} > T \rightarrow \text{pixels are not homogeneous}$$

VI. RESULT & CONCLUSION

Image Segmentation technique discussed in above section implemented in MATLAB for X-Ray having present of Osteosarcoma. For Matlab code refer next section. Result shown in figure 6. It seems that k-mean and region growing image segmentation techniques are best suited to detect tumour bone from X-Ray image.

Code in Matlab

```

%% Region Growing
a=imread('D:\image\Xray.png');
t0=60;
th=t0 + ((max(a(:))+min(a(:)))/2);
for i=1:1:size(a,1)
for j=1:1:size(a,2)
if a(i,j) > th
sout(i,j)=1;
else
sout(i,j)=0;
end
end
end
a1=rgb2gray(a);
%% Sobel
imsobel=edge(a1,'sobel');
%% Prewitt
imprewitt=edge(a1,'prewitt');
%% Canny
imcanny=edge(a1,'canny');
%% K-means
I = im2double(imread('D:\image\Xray.png'));
F = reshape(I,size(I,1)*size(I,2),3);
K = 5;
CENTS = F( ceil(rand(K,1)*size(F,1)) ,:);
DAL = zeros(size(F,1),K+2);
KMI = 10;
for n = 1:KMI

```



```

fori = 1:size(F,1)
for j = 1:K
DAL(i,j) = norm(F(i,:) - CENTS(j,:));
end
[Distance, CN] = min(DAL(i,1:K));
DAL(i,K+1) = CN;
DAL(i,K+2) = Distance;
end
fori = 1:K
    A = (DAL(:,K+1) == i);
CENTS(i,:) = mean(F(A,:));
if sum(isnan(CENTS(i,:))) ~= 0 % If CENTS(i,:)
Is Nan Then Replace It With Random Point
NC = find(isnan(CENTS(:,1)) == 1);
% Find Nan Centers
ForInd = 1:size(NC,1)
CENTS(NC(Ind),:) = F(randi(size(F,1),:));
end
end
end
end
X = zeros(size(F));
fori = 1:K
idx = find(DAL(:,K+1) == i);
X(idx,:) = repmat(CENTS(i,:),size(idx,1),1);
end
T = reshape(X,size(I,1),size(I,2),3);
% Display Result
subplot(1,6,1),imshow(a),title('Original Image');
subplot(1,6,2),imshow(T),title('K-mean');
subplot(1,6,3),imshow(sout),title('Region Growing');
subplot(1,6,4),imshow(imsobel),title('Sobel');
subplot(1,6,5),imshow(imprewitt),title('Prewitt');
subplot(1,6,6),imshow(imcanny),title('Canny');

```

Result

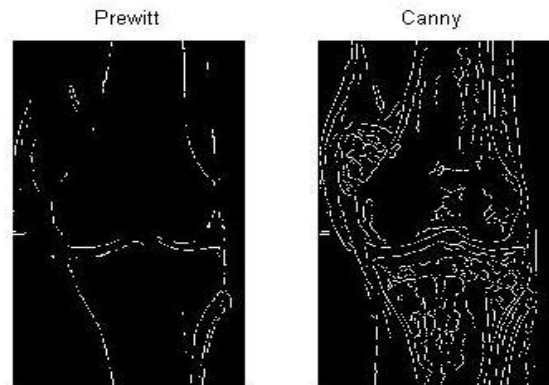


Figure 6: Comparison of K-means, Region Growing, Sobel, Prewitt and Canny

VII. FUTURE ASPECTS OF PROPOSED RESEARCH

Once interested object segmented from X-Ray or MRI image it provided to Convolution Neural Network Model of Deep Learning topredict the bone cancer type. For this, model should be trained with at least 10,000 datasets prior. Deep Learning have ability to auto detect the features discuss in Section 3 which is major reason to select deep learning, hence it is proven and trusted technique of Artificial Intelligence. This research helps radiologist and doctor to come out from dilemma of Osteosarcoma and Ewing – the common type of bone cancer.

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