

# Performance Comparison of Canny Edge Detection Algorithm and Bio-CAD Technique for Knee Images

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**Abstract.** Bio-CAD has been used to assist in Bio-Medical design and Modeling of images for analysis. In this work Bio-CAD technique along with Canny Edge detection algorithm has been proposed to model and analyze the Knee images. To find the correct boundary in noisy image of knee is still a difficult one. The proposed Canny Edge Detection (CED) algorithm has been used to detect the boundaries of knee image from the noisy knee image. The performance of proposed technique has been compared. The results show that the proposed Bio-CAD technique performs well and produced the better optimal solution Canny Edge Detection algorithm. This method is robust for all kinds of noisy images without prior knowledge of other properties. The performance of the both techniques was analyzed by calculating the probability error and edge length.

**Keywords:** bio-cad, edge detection, image segmentation, knee image, canny edge detection

## 1. Introduction

The knee joint is the largest joint in the body, consisting of 4 bones and an extensive network of ligaments and muscles. Injuries to the knee joint are amongst the most common in sporting activities and understanding the anatomy of the joint is fundamental in understanding any subsequent pathology. The knee is made up of four main bones- the femur (thigh bone), the tibia (shin bone), fibula (outer shin bone) and patella (kneecap). The main movements of the knee joint occur between the femur, patella and tibia. Each are covered in articular cartilage which is an extremely hard, smooth substance designed to decrease the frictional forces as movement occurs between the bones. The patella lies in an indentation at the lower end of the femur known as the intercondylar groove. At the outer surface of the tibia lies the fibula, a long thin bone that travels right down to the ankle joint. Each knee joint has two crescent-shaped cartilage menisci. These lie on the medial (inner) and lateral (outer) edges of the upper surface of the tibia bone. They are essential components, acting as shock absorbers for the knee as well as allowing for correct weight distribution between the tibia and the femur. Edge detection is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and object segmentation. This process detects outlines of an object and boundaries between objects and the background in the image. An edge-detection filter can also be used to improve the appearance of blurred or anti-aliased video streams. The basic edge-detection operator is a matrix area gradient operation that determines the level of variance between different pixels. The edge-detection operator is calculated by forming a matrix centered on a pixel chosen as the center of the matrix area. If the value of this matrix area is above a given threshold, then the middle pixel is classified as an edge. All the gradient-based algorithms have kernel operators that calculate the strength of the slope in directions which are orthogonal to each other, commonly vertical and horizontal. Later, the contributions of the different components of the slopes are combined to give the total value of the edge strength. Depending on the noise characteristics of the image or streaming video, edge detection results can vary. Gradient-based algorithms such as the Prewitt filter have a major drawback of being very sensitive to noise. Recent advances in computing technologies both in terms of hardware and software have helped in the advancement of CAD in applications beyond that of traditional design and analysis. CAD is now being used extensively in biomedical engineering in applications ranging from clinical

medicine, customized medical implant design to tissue engineering [4]. The primary imaging modalities that are made use of in different applications include, computed tomography (CT), magnetic resonance imaging (MRI), optical microscopy, micro CT, etc. each with its own advantages and limitations as described in [1]. Using data derived from these images, computer models of human joints for stress analysis, dynamic force analysis and simulation; design of implants and scaffolds etc. have been reported in published literature [5]. This effort to model human body parts in a CAD based virtual environment is also referred to as Bio-CAD modeling. Bio-CAD modeling plays an important role in this scaffold informatics modeling development by providing the basic morphology, anatomy and organization of the to-be-replaced tissue on which the pertinent biological design intents can be introduced.

## 2. Proposed Work Sequence

The Block diagram of the proposed system of Image segmentation technique is shown in Figure 1. The different process sequence is involved in this segmentation is given in below. The Original image is obtained from the CT scan image centre and then it will be incorporated by using Bio-CAD modelling and Image segmentation using canny edge detection algorithm. Both the results have been compared and analyzed and obtained the best optimal value.

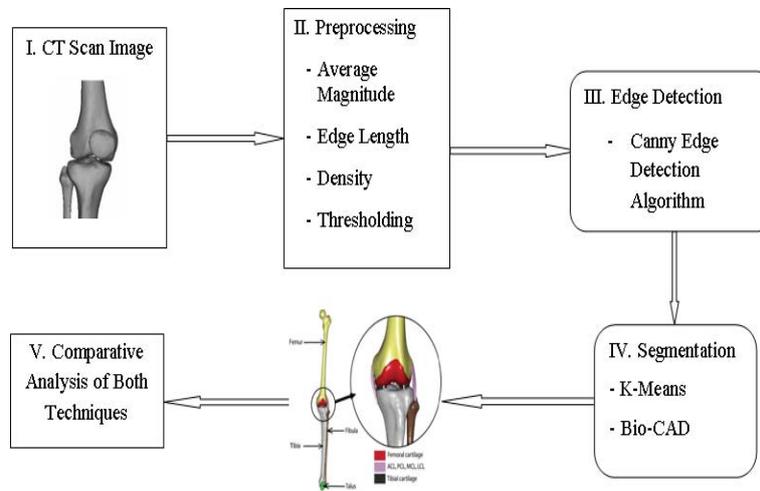


Fig.1. Flow diagram of proposed method

## 3. Canny edge detection algorithm

The Canny algorithm can be used an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges only once when a single edge exists for minimal response. According to Canny, the optimal filter that meets all three criteria above can be efficiently approximated using the first derivative of a Gaussian function.

$$GF(i, j) = \frac{1}{2\pi\sigma^2} e^{-\frac{i^2 + j^2}{2\pi\sigma^2}} \quad (1)$$

$$\frac{\partial GF(i, j)}{\partial i} \propto i e^{-\frac{i^2 + j^2}{2\sigma^2}} \quad \frac{\partial GF(i, j)}{\partial j} \propto j e^{-\frac{i^2 + j^2}{2\sigma^2}} \quad (2)$$

All the images are having some speckle and other noises. So there is a need of noise filtering using any techniques. In this work median filter is used to reduce the noise. If the scan box is approximately centered with knee, the median filter is shown below.

$$C_i^j = \text{Median}(\text{Pixel} = P) \quad (3)$$

Where, the speckle noise reduction can be done using the below expression

$$SN_1^n = \text{Pixel} B_1^{n-1} \quad (4)$$

### 3.1. Pre-processing of initial position of edge parameters detection

Step 1: Calculate the average magnitude

$$M(1, 2) = \frac{1}{M} \sum_{(1,2)}^n \sqrt{M_x(1, 2)^2 + M_y(1, 2)^2} \quad (5)$$

Step 2: Calculate the density of the edge length. The density of the edge length is calculated from

$$L(1, 2) = \frac{C(1,2)}{\max C(1,2)} \quad (6)$$

Where  $C(i,j)$  is the number of connected pixels at each position of pixel.

Step 3: Calculate the Initial position of map from summation of density of edge Length and average magnitude.

$$P(1, 2) = \frac{1}{2}(M(1, 2) + L(1, 2)) \quad (7)$$

Step 4: Calculate the thresholding of the initial position map. If

$$P(1, 2) > T_{max} \quad (8)$$

Then  $P(1, 2)$  is the initial position of the edge following. And then we obtained the initial position by setting  $T_{max}$  to 95% of the maximum value.

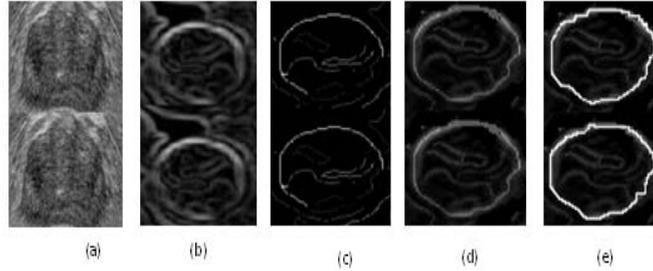


Fig.2. (a). CT scan Noisy Knee image (b). Average Magnitude Image (c). Density of the Edge Length  
(d). Initial Position map (e). Final Thresholding of edge map

From the above figure 2(a) to 3(e) and the analysis we can able to predict the proper and suitable initial position, then the proposed technique will follow the edges until the closed and shaped contour is formed.

### 3.2. Segmentation of Knee image.

The Canny approach to edge detection is optimal for step edges corrupted by white Gaussian noise. This edge detector is assumed to be the output of a filter that reduces the noise and locates the edges. The first step of Canny edge detection is to convolve the output image obtained from the aforementioned Law's texture  $t(i,j)$  with a Gaussian filter. The second step is to calculate the magnitude and direction of the gradient. The third step is no maximal suppression to identify edges. The broad ridges in the magnitude must be thinned so that only the magnitudes at the points of the greatest local change remain. The last step is the thresholding algorithm to detect and link edges. The threshold algorithm is used to detect and link edges. This idea is exploited for extracting objects' boundaries in unclear images. Knee image edge maps are shown in figure 3.

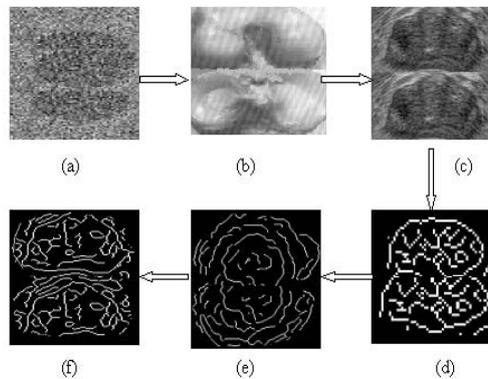


Fig.3. (a). CT scan Noisy Knee image (b). CT scan Initial Filtered image (c). Final Filtered image (d). Initial Edge detection Noisy image (e). Final Filtered edge detection (f). Final fine filtered Edge detection

## 4. Image Edge Detection Using Bio-Cad

CAD has been used to assist and help in engineering for design and analysis of images. And now CAD has been used for many advance and novel biomedical image applications ranging from Medical image modelling and analysis, clinical engineering and tissue engineering. Structure formation of Bio-CAD model for a knee images from the noisy image data with the CAD modalities. It is known as Bio-CAD image modelling with Boundary values. With this technique we can able to predict the Boundary and edge of Knee joints. Bio-CAD model of knee image from the CT scan noisy images are shown in Fig. 4.

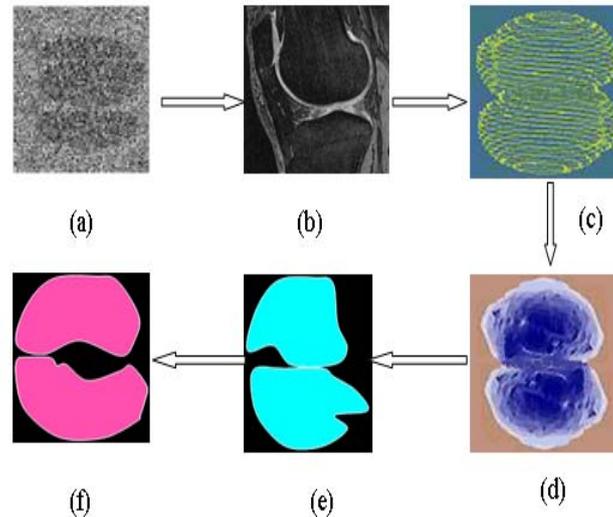


Fig.4. (a). CT scan Noisy Bio-CAD image (b). Right side Knee image (CT scan) (c). Filtered Bio-CAD Ultrasound image. (d). Edge detection Bio-CAD image (e). Filtered Bio-CAD edge detection. (f). Fine filtered Bio-CAD Edge detection

## 5. Results and Discussion

To further evaluate the efficiency of the proposed method in addition to the visual inspection, the proposed boundary detection method numerically using the Hausdorff distance and the probability of error in image segmentation. Where  $P(O)$  and  $P(B)$  are probabilities of objects and background in images. The objects surrounded by the contours obtained using the five snake models and the proposed method are compared with that manually drawn by skilled doctors from the Medical Hospital.

$$PE = P(O)P\left(\frac{B}{O}\right) + P(B)P\left(\frac{O}{B}\right) \quad (9)$$

From the above table 1 shows the average results of probability of Error in Image segmentation of canny edge detection algorithm and Bio-CAD segmentation techniques and also predicts the error difference for both the techniques.

Table 1. Average Results of Probability of Error in Image Segmentation

| S.No | Image illustration            | Canny Edge Detection (%) | Bio-CAD (%) | Error Difference DE (%) |
|------|-------------------------------|--------------------------|-------------|-------------------------|
| 1    | Ultrasound Noisy image        | 6.78                     | 6.38        | 0.40                    |
| 2    | Right side Knee image         | 9.83                     | 8.99        | 0.84                    |
| 3    | Filtered Ultrasound image     | 5.63                     | 5.61        | 0.02                    |
| 4    | Edge detection Noisy image    | 5.42                     | 5.37        | 0.05                    |
| 5    | Filtered Edge detection image | 4.71                     | 4.71        | 0.00                    |
| 6    | Fine Edge filtered image      | 4.62                     | 4.62        | 0.00                    |

## 6. Conclusion

The proposed technique for boundary detection and applied it to object segmentation problem in medical images. Our edge following technique incorporates a vector image model and the edge map information. The proposed technique was applied to detect the object boundaries in several types of noisy images where the well defined edges were encountered. Several synthetic noisy images were created and tested for the sake of

the known ground truths. The opinions of the skilled doctors were used as the ground truths of interesting objects in different types of medical images including prostates in ultra-sound images of knee images. Besides the visual inspection, all methods were evaluated using the probability of error in image segmentation. The results of detecting the object boundaries in noisy images show that the proposed technique is much better. We have success-fully applied the edge following technique to detect the object boundaries in medical images. The proposed method can be applied not only for medical imaging, but can also be applied to any image processing problems.

## 7. References

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