Hummers radiograph image segmentation using Normalized Cut

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ABSTRACT
Image segmentation techniques have been widely applied in diagnosis systems with medical image support. In this paper we propose the normalized cuts method for image segmentation problem, which is based on Graph Theory. These algorithms treat an image pixel as a node of graph, and consider segmentation as a graph partitioning problem. The Normalized Cuts algorithm measures both the total dissimilarity between the different groups as well as the total similarity within the groups. The pixel value of gray scale and color Images are considered for clustering dissimilarity and similarity group. The optimal solution of splitting points is easily computed by solving a generalized eigenvalue problem. The results of the proposed method are encouraging.

Keywords
X-Ray Bone Segmentation, Humerus Bone, Lateral elbow radiograph

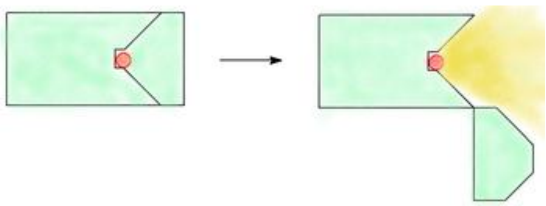
1. INTRODUCTION
The arm was fixed in a direction downwards, outwards, and slightly forward, so that the line of the humerus proceeded in a direction nearly parallel with the bone of the upper forelimb, extending from shoulder to elbow. It consists of a shaft and two enlarged extremities. The proximal end has a smooth round head that articulates with the scapula to form the shoulder joint. Just below the head are two rounded processes called the greater and lesser tubercles [1]. A humerus fracture can be classified by the location of the humerus involved: the upper end, the shaft, or the lower end. Certain lesions are commonly associated with fractures to specific areas of the humerus. At the upper end, the surgical neck of the humerus and anatomical neck of humerus can both be involved, though fractures of the surgical neck are more common. The auxiliary nerve can be damaged in fractures of this type. Mid-shaft fractures may damage the radial nerve, which traverses the lateral aspect of the humerus closely associated with the radial groove. The median nerve is vulnerable to damage in the supracondylar area, and the ulnar nerve is vulnerable near the medial epicondyle, around which it curves to enter the forearm [2].

The normalized cut (NCut), proposed by Shi and Malik [3], provides a rigorous computational foundation for image segmentation problems. A graph is constructed from the image such that the pixels constitute the vertex set, connected by weighted edges representing similarity between nearby pixels. This formulation allows the image segmentation problem to be treated as a graph partition of the vertex set. The partition measure associated with the NCut seeks to simultaneously minimize the cross segment connectivity and maximize the within segment association. The normalized cut criterion effectively suppresses the spuriously small segmentations that arise in minimum cut formulations.

The goal of this work is to detect perceptually significant groups. The small variations and details are treated later. Different image features like intensity, color, texture, contour continuity, motion are considered as the features for the proposed algorithm.

2. ABOUT RADIOGRAPHY
Radiography, x-ray as it is most commonly known, is the oldest and most frequently used form of medical imaging. X-ray imaging is the fastest and easiest way for a physician to view and assess bones. At least two images at different angles are taken and often more images are needed if the problem is around a joint (knee, elbow or wrist). X-rays play a key role in assessing for bone injuries, joint pain, and suspected bone masses or tumors [4].

Radiography involves exposing a part of the body to a small dose of radiation to produce an image of the internal structures on x-ray film. When x-rays penetrate the body, they are absorbed in varying amounts by the different tissues. Ribs, for example, will much of block the radiation and, therefore, appear white or light gray on the image. Fat tissue and air will appear darker because more radiation can pass through these tissues and expose the x-ray film. One design is best thought of as being like a torch. The radioactive source is placed inside a shielded box; a hinge allowed part of the shielding to be peeled back exposing the source so allowing the photons to leave the radiography camera. A torch type camera, which uses a hinge Red, represents the radioactive source; blue/green, the shielding; and yellow, the gamma rays.



3. RELATED WORK

3.1 Normalized Cuts and Image Segmentation
In this paper, propose a new graph-theoretic criterion for measuring the goodness of an image partition the normalized cut. The minimization of this criterion can be formulated as a generalized eigenvalue problem. The eigenvectors can be used to construct good partitions of the image [5].

3.2 Shape–Based image segmentation using Normalized cut
In this paper, our main contribution is to improve the performance of the normalized cut by introducing the shape information. Like most shape-based methods, the proposed method can correctly segment the object, even though a part

of the boundary is missing or many noisy regions accompany the object. Besides, another advantage of the proposed method is that the eigenvectors from the normalized cut can generate the parameters of the shape model directly [6].

4. PROPOSED METHOD

Humerus bone is a highly heterogeneous and anisotropic living tissue with composition and structure varying, depending on the skeletal site, function, age and type of vertebrate species. Also, bone is a hard matrix of calcium salts deposited around protein fibers with ideal hardness, moderate elasticity, limited plasticity and brittleness for different body part movements.

In this paper we present a technique that reduces the computational cost while yielding the exact continuous optimal solution. We propose a new graph-theoretic criterion for measuring the goodness of an image partition the normalized cut. The minimization of this criterion can be formulated as a generalized eigenvalue problem; the eigenvectors of this problem can be used to construct good partitions of the image and the process can be continued recursively.

Segmentation of bones in x-ray images is an important step in medical diagnosis, surgery, and treatment. Algorithms for segmentation of a single bone in x-ray images may not be robust enough, and the quantitative segmentation results are seldom reported. This leads to the proposed Method: Humerus radiograph image segmentation using Normalized Cuts.

A graph $G = (V, E)$ can be partitioned into two disjoint sets, A, B. The degree of dissimilarity between these two pieces can be computed as

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

one that minimizes this cut value. Finding the minimum cut is a well-studied problem and there exist efficient algorithms for solving it. However, the minimum cut criteria favors cutting small sets of isolated nodes in the graph, and gives bad partition in some cases such as Fig 2.

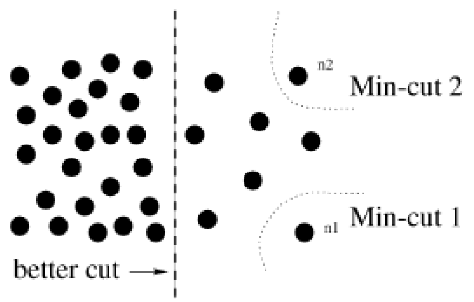


Figure 2: A case where minimum cut gives a bad partition.

5. ALGORITHM

Given an image sequence I. Construct a weighted graph G = (V, E) whose each node is each pixel of the image I. Let N be the number of nodes (pixels), i.e., |V|.

Step 1

Construct an N × N symmetric similarity matrix W as:

$$w_{ij} = \exp\frac{-\|F(i)-F(j)\|_2^2}{\sigma_I^2} * \begin{cases} \exp\frac{-\|X(i)-X(j)\|_2^2}{\sigma_X^2} \\ 0 \end{cases}$$

$$\text{if } \|x(i)-x(j)\|_2 < r$$

where X(i) is the spatial location of node i, i.e., the coordinates in the original image I, and F(i) is a feature vector defined as:

- F(i) = 1 for segmenting point sets,
- F(i) = I(i), the intensity value, for segmenting brightness (gray scale) images,
- F(i) = [v, u · s · sin(h), v · s · cos (h)](i), where h, s, v are the HSV values, for color segmentation,
- F(i) − [$|I*f_1|$, ..., $|I*f_n|$](i), where the f_i are DOOG filters at various scales and orientations, for texture segmentation.

Let $d_i = \sum_j w_{ij}$ be the total connection from node i to all other nodes.

Construct an N × N diagonal matrix D with d on its diagonal.

Step 2

Solve a generalized eigen system,

$$(D - W)\, y = \lambda D y,$$

and get an eigenvector with the second smallest eigenvalue. Fortunately, matlab has a function, eigs, to solve generalized eigensystems.

Step 3

Use the eigenvector to bipartition the graph. In the ideal case, the eigenvector should only take on two discrete values, and the signs tell us exactly how to partition the graph ($A = \{V_i | y_i > 0\}$, $B = \{V_i | y_i <= 0\}$).

However, y is relaxed to take real values; therefore, we need to choose a splitting point. There are several ways such as

- Take 0
- Take median
- Search a splitting point which results in that Ncut (A, B) is minimized.

The splitting point which minimizes Ncut value also minimizes

$$\frac{y^T (D - W) y}{y^T D y}$$

where y = (1 + x) − b(1 − x) where b = k/(1 − k) where

$$k = \frac{\sum_{x_i > 0} d_i}{\sum_i d_i}$$

where x is an N dimensional indicator vector, $x_i = 1$ if node i is in A and -1, otherwise.

To find the minimal Ncut, we need to try different values of splitting points. The optimal splitting point is generally around the mean value of the obtained eigenvector. Fortunately, matlab has a function, fmin search, which is suitable for this purpose.

Step 4

Repeat bipartition recursively. Stop if Ncut value is larger than a pre-specified threshold value (Large Ncut value means that there is no clear partition point any more). Furthermore, stop if the total number of nodes in the partition (Area) is smaller than a pre-specified threshold value (this is another criteria added newly to the paper's algorithm.)

6. EXPERIMENTS AND RESULTS

Gray scale Image

Fig shows the result of segmentation of a gray scale image.

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Figure 3: Results of segmentation

Figure 3: (a) shows the gray scale original image of size 100x67. Image intensity is normalized to lie within 0 and 255. Subplots (b)-(d) show the components of the partition with Ncut value less than 0.14, Area size more than 220.

Color Image

Fig 4. shows the result of segmentation of a color image.

Fig (a)

Fig (b)

Fig (c)

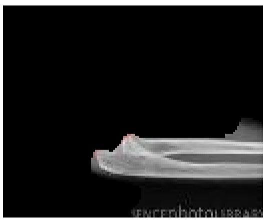


Fig (d)

Figure 4: (a) shows the color original image of size 100x67. Each RGB intensity is normalized to lie within 0 and 255. Subplots (b)-(d) show the components of the partition with Ncut value less than 0.21, Area size more than 120.

7. CONCLUSION

The algorithm runs exceedingly fast and can produce results in seconds. From the results projected, it is evident that the proposed method is an improved version to segment bone images. The normalized cut criteria for segmenting the graph. Normalized cut is an unbiased measure of disassociation between subgroups of a graph and it has the nice property that minimizing normalized cut leads directly to maximizing the normalized association, which is an unbiased measure for total association within the subgroups. In finding an efficient algorithm for computing the minimum normalized cut, we showed that a generalized eigenvalue system provides a real valued solution to our problem.

A computational method based on this idea has been developed and applied to segmentation of gray scale and color Hemerus Images. Results of experiments on real and synthetic images are very encouraging and illustrate that the normalized cut criterion does indeed satisfy our initial goal of extracting the big picture of a scene.

8. REFERENCES

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