Utilizing k-means clustering to extract bone tumor in CT scan and MRI images

Widad Dhahir Kadhim¹, and Rabab Saadoon Abdoon²

¹University of Babylon, College of Science, Department of Physics, Iraq
²University of Babylon, College of science, Department of Physics, Iraq

* widaddhahir9@gmail.com

Abstract. Segmentation is one of the most significant parts of medical image processing. In image segmentation, the digital image is part of multiple sets of pixels. Magnetic Resonance Imaging, MRI and CT scanning is very important imaging techniques to explore the inner physiological constructions of the body noninvasively. A bone tumor is one of more life-threatening diseases, so exact detaching of the tumor regions is a pressing need. In this work, the K-means algorithm is employed on six MRI and CT scan images with different numbers of clusters. As well as many morphological operations like opening and dilation were applied after extract the fine tumor areas effectively. The results and the calculated surface areas of the separated tumor regions were compared to the radiologist delineation and the percent relative differences were found ranged from (0.63-1.75) % for MRI images and (0.34-1.51) % for CT scan images. This result indicates the high-quality performance of the adopted segmentation clustering-based method.

Keywords: K-means, Segmentation, MRI, CT scan, Bone tumor.
The grown-up human skeleton features a sum of 213 bones, [1]. The bones of the skeleton is characterized by save support for the rest of the body, allow locomotion, by movement imparting levers for the muscles, protection inner organs and structures, make acid-base balance and maintenance the mineral homeostasis, work a store of growth factors and cytokines, and supply the environment for hematopoiesis inside the marrow place area[2]. The bone tumor is masses of tissue that are shaped inside the bone cells [3]. Discovered two kinds of bone tumors, Benign (Noncancerous) and Malignant (Cancerous) [4]. Becomes the benign tumor very large and press on nearby tissues, they don’t normally reoccur, when removed by a medical procedure. Includes the malignant tumor a bigger nucleus that looks different from an ordinary cell’s nucleus after they are removed can reoccur [5, 6]. Bone tumors influence which bone in the body and evolve in which part of the bone. the growth bone tumor make benign tumor becomes weaken bone and smash healthy tissue [3]. CT has transformed a lot of medical imaging by giving three-dimensional views of the member or body region of interest [7]. In Computed tomography (CT), to detection diverse diseases and conditions utilizes sophisticated x-ray technology. CT scanning is quick, painless, noninvasive and precise. In emergency cases, it can uncover quickly enough. Diagnose issues such as cancer, cardiovascular sickness, infectious disease, appendicitis, trauma, and musculoskeletal disorders [8]. MRI is an imaging way that activates a powerful magnetic field and radiofrequency waves to discern organs, flaccid tissues, and bones. There is no being exposed to ionizing radiation as in usual x-rays and computed tomography (CT). To get a variety of disorders, such as strokes, tumors, spinal cord injuries, multiple sclerosis, and eye or internal ear problems use MRI. As well as, MRI has the major feature is not exposing patients to radiation. In the differential prognosis of benign bone pests such as simple or aneurysmal bone cysts magnetic resonance imaging (MRI) may be very helpful [9]. In this work, the implementation of one segmentation method to detect and extract bone tumor regions in CT scan and MRI images of different orientations and methods: clustering K-means.

1. Introduction

K-Means is from the many of the difficult clustering methods, used clustering algorithm to partition data into a determined number of clusters. K- Means classify the pixels into clusters being based on their intensity values. Every cluster is usually characterized by constant intensity. k- means clustering is often fitting for medical image segmentation for the reason that a variety of clusters (k) is typically regarded for photos of precise areas of human anatomy, in biomedical programs, the spatially various depth change of a biomedical structure is typically caused by inhomogeneity inside the method of image acquisition, including the inhomogeneous distribution of the comparison agent in CT imaging or inhomogeneous distribution of the magnetic discipline gradient in MRI imaging. a preliminary segmentation is obtained through the simple k-mean algorithm, the ordinary probability function is maximized on a point-point foundation, with the mean and the variance of every cluster is up to date after every iteration[10]. When the changes in the cluster seeds from one level to the next are close to zero or smaller than a pre-specified value algorithm stops. Each object is assigned to just one cluster [11]. K-means means algorithm aims to reduce the target function that represents the function of squared error which obtained by [12].

\[ J(V) = \sum_{i=1}^{c} \sum_{j=1}^{c_i} ||y_i - v_j||^2 \quad \ldots \ldots (1) \]
Where: ‘c’ is the number of cluster centers while ‘ci’ is the number of data points in the ith cluster and ‘\|xi - vj\|’ is the Euclidean distance among xi and Vj. Many researcher were adopted this algorithm to extract abnormal regions in the medical images for difference body organs like [13-21].

3. Morphological Operations

Morphological operators are used in image processing due to their robust performance in preserving the shape of a signal, while suppressing the noise [22]. The basic idea in mathematical morphology is to convolve an image with a given mask (known as the structuring element) [23].

There are two basic morphological operators: erosion and dilation, opening and closing are two derived operations in terms of erosion and dilation. Here a brief introduction to the morphological operations [24]:

The primitive operations of mathematical morphology, dilation, and erosion, are based on set theory. A binary image is considered as a set of points (white region) containing in some universal set (background, or black region). The morphological structuring element is a second set of points required for the transformation. The shape of this structuring element defines the results produced by the morphological filter.

1- Opening: The opening consists of an erosion followed by dilation and can be viewed as the union of all points in B everywhere that B is contained in X.

The opening is denoted in terms of the primitive operations of dilation and erosion as simply [25]:

\[ X^{\text{op}} = (X \ominus B) \oplus B \] ……(2)

2- Dilation: Considers the dilation of a binary image by a simple hexagonal structuring element B. This dilation can be expressed as the locus of centres x of the structuring element B_x where the intersection of the image X and B_x is nonempty. This is often referred to as B_x hitting X and, therefore, the name “hit” is often applied to this operation. It may be expressed as [26]:

\[ X \oplus B = \{ x : B_x \cap X \neq \emptyset \} \] …….(3)
4. **Experiments and methodologies**

The method was executed by using the Mat lab program; the proposed procedure to achieve the extraction of the tumour regions is summarized in Figure (1).

![Diagram of the proposed work](#)

**Figure 1.** The blueprint of the proposed work.
5. **Input Dataset**

The experimental images are three bone MRI images and three bone CT scan images with for the sizes of (244 x 443), (142 x 174), (225 x 225), (261 x 342), (288 x 267), (291 x 273). The adopted images were acquired from different resources: Hila teaching hospital and websites. Figure 2 presents the experimental images.

![Input bone images: MRI in first row and CT scan in the second row.](image)

**Figure 2.** Input bone images: MRI in first row and CT scan in the second row.

6. **Results and discussion in this study**

The results of implementing the proposed work are as follows:

6.1 **K-Means Algorithm**

K-Means clustering algorithm was implemented with different number of clusters for the six input images. It is found that the proper number of clusters were (3, 5, 6, 6, 3, and 5) for the images (bon1, bon 2, bon 3, bon 4, bon 5 and bon 6) respectively. Figure (3) represent the results of implementing this method.
Figure 3. Results of implementing K-means algorithm: (a) for MRI and (b) for CT scan.

Figure (3), the first row represents the segmented image, the second row represents the image of the abnormalities cluster and the third row represents the extracted abnormal regions.
6.2 Radiologists Delineation
By viewing the results images the manual delineation to extract the abnormal regions is show in the figure (4).

![Figure 4. Radiologist delineation of the abnormal region of bone: (a) MRI images, (b) CT scan images.](image)

Figure 4. The first row represents the original image, the second row represents the manual delineation regions images and the third row represents the extracted abnormal regions in grey.

**Schedule (1):** The calculated surface area of the extracted tumor regions utilizing the K-Means algorithm and radiologist delineation as well as the percent relative differences%

| Image  | Modality  | Extracted Surface Area K-Means (pixel) | Surface Area Radiologist (pixel) | Percent Relative difference% |
|--------|-----------|----------------------------------------|----------------------------------|-----------------------------|
| Image1 | MRI       | 407                                    | 400                             | 1.75                        |
| Image2 | MRI       | 2061                                   | 2048                            | 0.634765625                 |
| Image3 | MRI       | 4342                                   | 4372                            | 0.6861848124                |
| Image4 | CT Scan   | 6780                                   | 6757                            | 0.3403877746                |
| Image5 | CT Scan   | 7132                                   | 7242                            | 1.5189174261                |
| Image6 | CT Scan   | 4845                                   | 4901                            | 1.1426239543                |
6.3 Comparison
By comparison the results of tumour region in grey that obtained from the manual delineation the abnormal region and the tumour region in grey that obtained from the applying the K-Means algorithm.

![Comparison Image]

**Figure 5.** Represent the comparison between the original images in the first row, the second row extracted abnormal regions in grey by K-Means algorithm and the third row represent the extracted abnormal regions in grey by manual delineation.

Conclusion
In this work, clustering based segmentation method K-Means, was implemented to extract the bone tumour in MRI and CT scan images with different number of clusters. From the result. It was cleared that the proper number of clusters were (3, 5, 6, 6, 5, 3) for MRI and CT images respectively. As well as the results insure the high quality performance of the adopted segmentation method since the present relative differences with the radiologist delineation were ranged from (0.63 to 1.75) % for MRI images and for CT scan images were ranged from (0.34 to 1.51) %.

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