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Bone Cancer Detection from MRI Scan Imagery Using Mean Pixel Intensity

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***Abstract*—Cancer is a dangerous disease, which is caused because of unregulated cell growth. After many researches, almost 100 different types of cancer has been detected in human body. Out of these, one of the most widely spread is bone cancer, which leads to death. The detection of bone cancer is very critical and which has no anticipation. Presently, most of the study is done by using data mining methods and the image processing techniques for medical image analysis process. The data and the knowledge collecting from large databases and related websites have been predictable by many scientific researchers. Association rule mining, supports vector machines, fuzzy theory and probabilistic neural networks and learning vector quantization are the mostly used methods for detection and classification of bone cancer. This paper used *k*-means clustering algorithm for bone image segmentation. The segmented image is further processed for bone cancer detection by evaluating the mean intensity the identified area. Threshold values are proposed for the classification of medical images for the presence or absence of bone cancer. This method uses jpeg images, but also applicable for original format of DICOM (digital imaging communication of medicine) medical images if any modifications are done. The results using this method gives 95% accuracy with less computational time.**

Keywords–Bone cancer tumor; mean pixel intensity; k-means clustering; detection.

I. Introduction

Cancer, which makes unfettered cell growth, will subdivide the cells and grow wildly, forming malevolent tumors, and assault nearby parts of the body. This tumor can grow and impede the digestive, nervous, and circulatory systems and they can liberate hormones that amend body function. Cells treated as cancer cells because of injure to DNA. In a regular cell, when DNA damaged the cell upkeep the damage or the cell dies. If the damaged DNA isnt repaired, and die that damaged DNA causes to making unnecessary new cells. Cancer cells often moves to other parts of the body, and begin to produce tumors that reinstate to regular tissue. This process is called metastasis. After that cancer cells get into the bloodstream or lymph vessels of human body.There are different types of cancer that are detected in human body. If the tumor is directly affected to bone then that type of disease is known as Bone cancer. bone cancers are called sarcomas. Sarcomas are initiate in muscle, bone, fibrous tissue, blood vessels, fat tissue, as well as some other tissues. They can expand anyplace in the body.

Bone refashion activity is only due to Cancer cells in the Bone. Normal bone is indefatigably being amended, or conked out and rebuilt. Cancer cells offend the balance for growth and formation of cell in bone. If cancer cells are in the bones, then the structure of bone is bent at a higher rate when compared to normal bone rate. Mostly bone cancer will be of primary or secondary . Primary bone cancer occurs in the bone. Whereas secondary bone cancer happens anywhere in the Body.

In bone enlargement process, Bone precise alkaline phosphates plays a vital role for detecting the increase of bone growth activity. Patients with bone cancer will be referred to an oncologist. The following tests will be suggested: Bone scan: A liquid that contains radioactive substance will be injected into the vein. This diagnosis in typical areas and will be detected by the scanner. The image is recorded on a big screen. Computerized Tomography (CT) scanner for enlarging 3-dimensional image uses digital geometry for taking representation of the inside object. The CT scan gives the result about, whether the bone cancer well move to other parts are not. Magnetic Resonance Imaging (MRI) mechanism uses a magnetic field and radio waves to create exhaustive images of the body, which is a explicit bone or part of a bone. Positron Emission Tomography (PET) scan uses emission, or nuclear medication imaging, to produce 3D, color images of the practical processes within the human body. X-rays can detect harm caused to the bone and also detect new cells. Finally, the bone biopsy is conducted by collecting a sample of bone tissue for cancer cells.

The American Cancer Society (www.cancer.org) estimates for cancer of the bones and joints for the year 2014 as about 3,020 new cases will be diagnosed, 1,460 deaths due to bone cancers are expected. Primary cancers of bones account for less than 0.2% of all cancers. In adults, over 40% of primary bone cancers are chondrosarcomas. This is followed by osteosarcomas 28%, chordomas 10%, Ewing tumors 8%, and malignant fibrous histiocytoma/fibrosarcomas 4%. The remainder of cases are several rare types of bone cancers. In children and teenagers less than 20 years osteosarcoma is 56% and Ewing tumors is 34% are much more common than chondrosarcoma is 6%. Chondrosarcomas develop mostly in adults, Chordomas are also most common in adults. Less than 5% of cases occur in patients younger than 20.

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Both osteosarcomas and Ewing tumors occur most often in children and teens. Rebecca Siegel et al. [17] estimated the number of persons going to be effected by different cancers and overall of deaths of cancers effected persons in 2014 that survey details shown in Table 1.

Segmentation is an approach in which pixels are grouped to form a cluster, which is closest among all clusters. Pixels having homogeneous characteristics belong to the same cluster and pixels must follow the homogeneity criteria in the same cluster. To perform clustering and classification fuzzy C-mean clustering, supports vector mechanism, fuzzy theory, probabilistic neural networks and learning vector quantization methods are used in those methods proper segmentation of medical images is not up to the mark and accuracy levels are less. In cluster based image segmentation techniques, number of clusters need to specify prior to process and which finally reduces the atomicity of the technique. one more major drawback those methodologies are noise sensitive so that the accuracy and performance goes down. To overcome that problem in this paper new approach is implemented for bone cancer detection using mean pixel intensity thresholding.

The fundamental methodology used in this paper can be explained as follows. Initially, we consider bone scan images. The bone tumor part is extracted from the images and uses *k*-means technique. The tumor part is selected from the original image. After that the number of pixels N in the cancer part and sum of pixel intensities S are calculated. Using number of pixels and sum of pixel intensities the mean intensity is calculated.

This paper is organized as follows. Section II describes the related work done to date. We briefly describes the methodology in Section III. Section IV provides the experimental results. A conclusion is drawn in Section V.

II. Related Work

In this paper a method is introduced to detect bone cancer by using k-means clustering and mean pixel intensity thresholding. Om Prakash Verma and Madasu Hanmandlu [1], introduced a single seeded region-growing technique for color image segmentation. For segmenting the color image intensity based similarity index for the grow formula and Otsus adaptive thresholding is used to the stopping criteria for the grow formula. In this method they compared the Otsus adaptive thresholding with the watershed technique, finally results are compared based on Lius F-factor. They have not conducted post segmentation process region merging steps which leads to computational time increase. E. A. Zanaty [2] proposed a new method for automatic threshold for segmenting MRI images, if images with poor contrast there may be a chance of losing information in boundaries to overcome that problem. Here, homogeneity criterion and probability are calculated for each pixel for getting the more accuracy segmentation for gray matter or white matter MRI datasets.

TABLE I: Expected number of persons suffers with cancer in 2014.

Cancer type	Estimated new cases in 2014			Estimated deaths in 2014		
	Total	Male	Female	Total	Male	Female
Bones	3,020	1,680	1,340	1,460	830	630
Eye	2,730	1,440	1,290	310	130	180
Breast	235,030	2,360	232,670	40,430	430	40,000
Colon	6,830	48,450	48,380	50,310	26,270	24,040
Lung	224,210	116,000	108,210	159,260	86,930	72,330
Brain	23,380	12,820	10,560	14,320	8,090	6,230

Jie Wul et al. [3] proposed a method for implementing a texture feature-based computerized method for segmenting limb using SRG algorithm for segmenting the lung parenchyma from lung CT images based on the region of interest (ROI). In preprocessing stage each area in lung is separated using ROI after that each part like tumor/node and cancer part is examined clearly. This method is helpful for radiologist in early diagnosing of lung diseases. This method is also applicable for liver, brain or spine.

Kristina Bliznakova et al. [4] proposed an new method and application tool for liver volume and evaluation of the left over function of the liver former to the involvement of the surgeons devoted for patient with persistent kidney disease liver volume segmentation, visualization, and virtual cutting for liver CT scan images is done. For CT image segmentation multi seeded region growing technique is used. They implemented the software application that processes the results to produce a three-dimensional (3D) image of the region where easy and fast justification of the segmentation results. Ali Qusay Al-Faris et al. [5] planned MRI breast tumor segmentation for that they developed a customized automatic seeded region growing based on Particle Swarm Optimization (PSO) image clustering system has been presented. For pre-processing level set active contour and morphological thinning methodologies are used. Here, PSO clusters intensities are involved in the automated SRG initial seed and threshold value selection. This method shows high performance compared with ground truths. Jianping Fan et al. [6] implemented an automatic seeded region growing algorithm for effectual pixel labeling technique and an automatic seed selection method for segmentation process. Mohd Saad et al. [7] presents an automatic segmentation of brain lesions from diffusion-weighted magnetic resonance imaging using region growing approach. Similarity measure pixel intensity and pixel mean values differences are used to detect the lesion region using region splitting and merging and for automation process the thresholding technique is used. Results when compared to semi automated region growing show that the automated region growing results are efficient. Shilpa Kamdi and Krishna [8], after examination of achievements, troubles being encountered, and the open issues in the research area of image segmentation used edge, threshold and region based techniques compared to other segmentation techniques like Laplacian and gradiant region growing is noise free.

In the work done by Sunil Kumar and Ashok Kumar [9], an exact Lung segmentation using region growing algorithm for early detection of lung diseases and lung cancer and made the diagnosis became simpler. This method is based on region of interest, lung area is separated from background. Dina Aboul Dahab et al. [10] developed probabilistic neural network model that is based on learning vector quantization with MRI images of brain and data analysis and manipulation techniques are used for classification and detection of brain tumor. They used edge detection algorithm and region of interest take a part in identification exact tumor part. In this paper they achieved 100% accuracy for brain tumor classification.

Sasikala and Vasanthakumar [11] used *k*-means clustering algorithm to detect cancer from on multi resolution representation of the original MRI images, ultrasound and mammogram for segmenting the breast cancer cell they used the *k*-means clustering techniques. After extracting the cancer cell they identified the stages of breast cancer using American Joint Committee on Cancer (AJCC) and Tumor Nodes Metastasis System TNM. For finding the accuracy sensibility they calculated the mean, standard deviation, variance and RMS values calculated. Juliet R Rajan and Jefrin J Prakash [12] explained a new methodology using a data mining for predict the lung cancer at an early stage. Implemented new data mining tool that works wisely in pre-diagnosing lung cancer at early Stages. This tool is constructed by using artificial neural networks.

Rajeswari and Sophia Reena [13] planned new method for classifying the tumor parts using fuzzy neural network that can classify easily using association ranking MAPSTD. Here, liver cancer cell classification is done using support vector mechanism and fuzzy neural networks classifiers. This method is applied on liver cancer patients datasets. Michael Feldman et al. [14] introduced a Boosted Bayesian Multi Resolution (BBMR) classifier for computerized recognition of CaP from digitized histopathology, a obligatory ancestor to automated Gleason grading. To the best of our knowledge, this research represents the first endeavor to automatically find regions involved by CaP on digital images of prostate biopsy needle cores. This approach reduces the time of computation by 4-6 times compared to non multi-resolution based approaches as pixel based classification accuracy is high.

Karthikeyan Ganesan et al. [15] proposed computer-aided diagnosis for brain cancer images segmentation and implemented premature method for segmenting the brain tumor part using the *k*-means algorithm for mammograms. This methodology improves accuracy and computational time. Conventional decision tree approach is used for datasets. Samir Kumar Bandyopadhyay and Tuhin Utsab Paul [16] applied *K*-means clustering and DBSCAN for segmenting brain tumor from MRI images of human brain. After segmentation they compared the results of both algorithms and concluded that the computational time is exponentially increasing in DBSCAN.

III. BONE CANCER FORMATION

Bone is the supporting skeleton of body and is hollow. The outer part of bones is a arrangement of tough tissue called matrix against calcium salts are laid down. The hard out layer is made with cortical bone, it covers trabecular bone inside, outside of bone covered with periosteum. Some bones are hallow and space is called medullary cavity which contains the soft tissue called bone marrow. Endosteum is act as a tissue lining. At each end of the bone is a region of a softer shape of bone-like tissue called cartilage, it is softer than bone that is made of fibrous tissue matrix assorted with a gel-like stuff that does not enclose much calcium. Most bones get going out as cartilage. The body then put downs calcium onto the cartilage to form bone. After the bone formation, some cartilage may stay at the ends to act as a bolster between bones. This cartilage, along with ligaments and some other tissues join bones to form a joint. Bone itself is very stiff and muscular. Bone is able to hold up as much as 12,000 pounds per square inch. It takes as much as 1,200 to 1,800 pounds of pressure to break the thigh bone. The bone contains 2 kinds of cells. The osteoclast is the cell that form new bone, and the osteoclast is the cell that softens old bone. some bones the marrow is greasy tissue. The marrow in other bones is a concoction of fat cells and blood-forming cells. The blood-forming cells fabricate red blood cells, white blood cells, and blood platelets. Other cells in the marrow include plasma cells, fibroblasts, and reticuloendothelial cells.

The accurate cause of bone cancers is not known. Scientists have made great progress in sympathetic how certain changes in a persons DNA can cause normal cells to turn into cancerous. It may influence risk for just beginning certain diseases, plus some kinds of cancer. DNA is divided into genes. Genes clutch the recipes for of proteins, the molecules that find out all cell functions. Some genes controls when cells grow and divide. Genes that endorse cell division are called oncogenes and slow down cell division or create cells die at the right time are called tumor suppressor genes. Cancers can be caused by DNA defects that start ontogenesis or inactivate tumor suppressor genes. Some people with cancer have DNA mutations that they inborn from a parent.

The American Joint Commission on Cancer system is used to stage all bone cancers. Factors to decide stage by the initials T, N, M, and G. T stands for description of tumor (its size one spot on the bone), N stands for extend to lymph nodes, M is for metastasis move to distant organs, and G is for the tumors grade, higher grade if more abnormal the cells appeared. Higher grade cancers have a tendency to grow and extend more quickly than lower grade tumors.

IV. EXPERIMENTATION METHODOLOGY

The primary purpose of this processing of bone cancer imagery is to identify the region of bone cancer and evaluate its mean gray scale pixel intensity of that region affected. The entire course of action employed is shown in the Fig 1. The pre-requirements for this methodology are scan imagery of bone with or without noise. When the image containing noises such as illumination variations, occlusions, and scale variations, deformation of objects and so on, is analyzed, the information retrieved may go haywire from original value. Hence, the image must be denoised.

Clustering is process in which pixels are classified based on the standardized characteristics. The pixels follow the homogeneity condition in the same cluster for constructing clusters based segmentation. At present mostly k-means [18-21] and seeded region growing algorithm [22] methods are used for image segmentation. K-means clustering is the mechanism deployed in this paper. It segregates the image such that the textures in a cluster have approximately same pixel values when compared with other clusters formed. K-means algorithm is an iterative technique which classifies objects based on attributes, features into k number of group. The grouping is done by minimizing the sum of squares of distances between data and the corresponding cluster centroid [19]. The k-means algorithm assigns each point to the cluster whose center(centroid) is nearest. The centre is the average of all the points in the cluster, that is, the arithmetic mean of its coordinates for each dimension separately over all the points in the cluster [20]. In order to anticipate a bone cancer tumor a higher range k-means algorithm is adopted to cluster the image into six segments using Euclidean distance metric to avoid local minima. Major draw backs for k-means are k-means cannot build non-convex shaped clusters and the number of cluster needs to be predefined. K-means is receptive to noise as small number of such data can significantly manipulate the mean value. The major problem for medical image segmentation is priory specification of the number of clusters, if set lower value for k it may lead to better results but, takes more number of iterations. Euclidean distance measures can unequally weight underlying factors and the computational time increases.

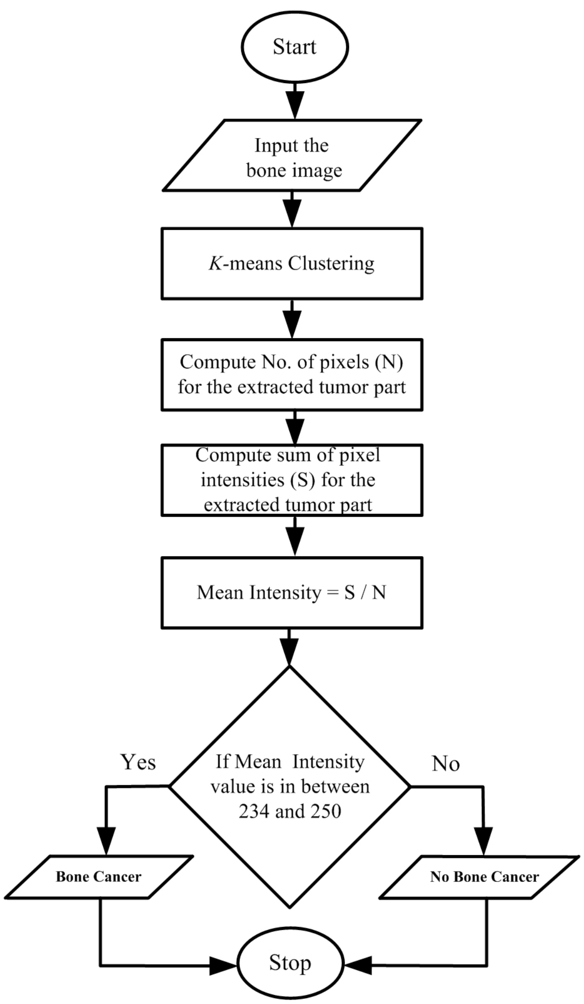


Figure 1: Experimentation Methodology.

The steps involved in the k-means clustering algorithm are: 1. Initially assign value for k that is number of clusters; 2. Erratically generate k clusters and decide the cluster centers, or directly create k random points as centers of clusters; 3. Each point is assign to nearest cluster center; 4. Regenerate the new cluster centers.

For the analysis, the MRI scan images of bone cancer are acquired from The Radiology Assistant Website (www.radiologyassistant.nl). A total of 400 bone cancer MRI images are used for the experimentation. Initially, the affected tumor part is extracted from the MRI scan image using k-means algorithm. Further, compute the number of pixels (N) and sum of pixel intensities (S) for the extracted tumor part. Finally, the mean pixel intensity value is computed by using equation (1). From the experimental analysis, it is established that the mean pixel intensity values lies in between 234 to 250.

$$\begin{aligned} &Intensity\ of\ cancer\ cell = \\ &Area\ of\ interest \times Mean\ pixel\ value\ Intensity \end{aligned} \tag{1}$$

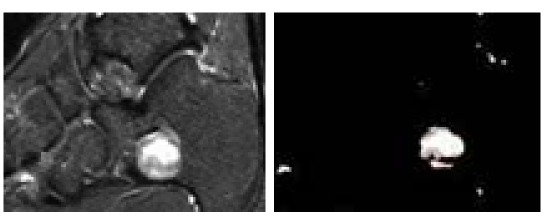
V. RESULT AND DISCUSSION

Bone cancer detection is one of the challenging tasks that researchers, doctors, academicians and so on of present day are experiencing. It is to be identified at the earlier stages to prevent the death toll rate to a greater extent. Many researches have put forward many theories which have turned to be inaccurate due to the lack of proper analysis and study of various parameters that involve in the formation of a bone cancer. Mining of data from MRI images is even more challenging and cumbersome task since it involves processing of not one but hundreds of MRI images in order to extract the required results.

The bone cancer images obtained from Radiology Assistant website (www.radiologyassistant.nl) are used to analyze for the identification of bone cancer. The radiologist Robin Smithuis proposed the radiology assistant for the Radiology Society of the Netherlands to afford state-of-the-art radiological education for radiology inhabitants and radiologists. The free accessibility of this information reflects the obligation of the Radiology Assistant to afford knowledge to wide viewers. In the experimentation, around 400 images are analyzed to compute the success rate of detection.

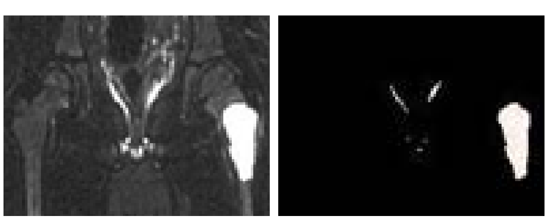
The segmentation process using k-means clustering is applied for the original images shown in Fig 2 (a), 3 (a), 4 (a) and 5 (a) respectively to detect the cancer affected part and the segmented images are shown in Fig 2(b), 3(b), 4(b) and 5(b) respectively. The entire process is implemented in MATLAB R2011a with image processing tool box, which provide image segmentation algorithms, tools and a comprehensive environment for data analysis, visualization and algorithm development.

In order to detect cancer/no-cancer mean pixel intensity values are extracted for the segmented images. This image mean intensity value plays an important role in the identification of cancer/no-cancer. As the affected tumor size increases the mean intensity value is observed to be varying. From experimentation on 400 images, it is observed and established that the mean intensity values for the identification of cancer/no-cancer lies in between 234 and 250. The experimental illustration clearly shows that, the proposed methodology outperforms with an average accuracy of 95%,



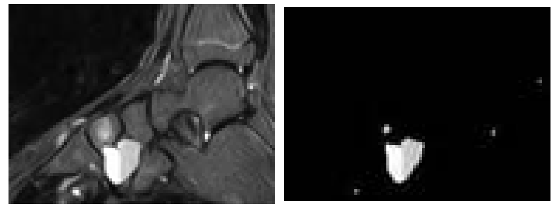
(a) MRI image of foot. (b) Segmented tumor part.

Figure 2: k-means clustering applied on Navicular bone of foot.



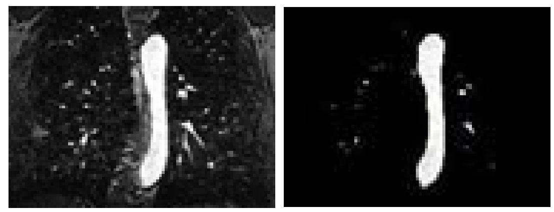
(a) MRI image of thigh. (b) Segmented tumor part.

Figure 3: k-means clustering applied on Femur bone of thigh.



(a) MRI image of foot. (b) Segmented tumor part.

Figure 4: k-means clustering applied on Cuneiform bone of foot.



(a) MRI image of thorax. (b) Segmented tumor part.

Figure 5: k-means clustering applied on Sternum bone of thorax.

shown in Table II.

The preliminary results shown in Table II comprises of a sample of 50 images, representing the detection of cancer/no-cancer. For illustration, let us consider image 11, its computed mean pixel intensity is 234, this value falls in the established range 0f 234 to 250. The predicted experimental result is cancer which is same as observed result. Hence, the prediction is true. Similarly, consider image 38, its computed mean intensity is 232. The predicted experimental result is no cancer and the observed result is cancer. Hence, the prediction is false.

VI. Conclusion

This paper mainly discussed about the detection of the bone cancer. It can be further extended to identifying the stages of cancer. Cancer is an important factor in the global burden of disease. The estimated number of new cases each year is expected to rise from 10 million in 2002 to 15 million by 2025, with 60% of those cases occurring in developing countries. This paper presents a formal mechanism for choosing mean pixel intensity values to discriminate between cancer/no-cancer for the images. An approach to segment a tumor or cancer part from an image using a single seed based on k-means algorithm for the extraction of bone tumor part. The extracted segmented image is further processed to evaluate the mean pixel intensity in the region of interest. Based on the mean pixel intensity value thresholding, detection of the bone cancer is more accurately achieved. In this, the computer-aided diagnostic system the bone cancer from the CT scan images or MRI images is proposed and is also applicable for original format

TABLE II: Mean intensity values for the images in database.

Image No.	Observed	Mean Intensity	Experimental	Prediction
1	cancer	234	cancer	True
2	cancer	245	cancer	True
3	cancer	234	cancer	True
4	cancer	241	cancer	True
5	cancer	238	cancer	True
6	cancer	241	cancer	True
7	cancer	248	cancer	True
8	cancer	242	cancer	True
9	cancer	240	cancer	True
10	cancer	242	cancer	True
11	cancer	243	cancer	True
12	cancer	240	cancer	True
13	cancer	247	cancer	True
14	cancer	235	cancer	True
15	cancer	239	cancer	True
16	cancer	240	cancer	True
17	cancer	239	cancer	True
18	cancer	241	cancer	True
19	cancer	245	cancer	True
20	cancer	242	cancer	True
21	cancer	238	cancer	True
22	cancer	240	cancer	True
23	cancer	239	cancer	True
24	cancer	248	cancer	True
25	cancer	240	cancer	True
26	cancer	240	cancer	True
27	cancer	242	cancer	True
28	cancer	245	cancer	True
29	cancer	237	cancer	True
30	cancer	238	cancer	True
31	cancer	239	cancer	True
32	cancer	242	cancer	True
33	cancer	241	cancer	True
34	cancer	246	cancer	True
35	cancer	237	cancer	True
36	cancer	243	cancer	True
37	cancer	242	cancer	True
38	cancer	232	No cancer	False
39	cancer	247	cancer	True
40	cancer	247	cancer	True
41	cancer	236	cancer	True
42	cancer	244	cancer	True
43	cancer	247	cancer	True
44	cancer	241	cancer	True
45	cancer	243	cancer	True
46	cancer	237	cancer	True
47	cancer	239	cancer	True
48	cancer	241	cancer	True
49	cancer	243	cancer	True
50	cancer	248	cancer	True

of DICOM (digital imaging communication of medicine) medical images.

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