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Survey of Various X-Ray Bone Image Segmentation Approaches

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Abstract- Photo segmentation is a foremost study subject considering the fact that it plays a major position in photo evaluation and understanding. Segmenting a snapshot is essentially the most difficult and tricky assignment due to the fact that there exist exclusive objects and a tremendous variants between them using a common framework. Thresholding is likely one of the simplest segmentation strategies. The drawback of thresholding methods is that they may be able to be utilized to a single-band photograph, equivalent to a gray-scale image or a single band of a multi-band photograph. Area headquartered ways have shown to be very useful and effective segmentation methods in photograph processing. Nevertheless, they've over-segmentation tendency, require handbook initialization and are touchy to noise. Clustering system can be used for multi-band pics; however the number of groups needs to be founded first. Classification-situated algorithm requires a training phase. Deformable units are less sensitive to noise than the opposite methods awarded in this paper, which make them compatible for problematic clinical picture segmentation problems. Atlas-situated approaches use prior potential in an effort to perform segmentation, but they are time-ingesting.

Keywords: X-Ray, Image Segmentation, Clustering, Classification.

I. INTRODUCTION

There exist many varieties of x-ray pictures, corresponding to natural x-ray photographs, angiograms, x-ray microscopic pictures, mammography images and fluoroscopic photos, and so on. Designated types of x-ray photographs, similar to angiograms, are acquired by means of inserting contrast agent in to the patient's blood to increase the contrast between the blood vessels and their neighboring tissues. Typical x-ray pix of the bone are essentially the most mainly used imaging modality for medical professionals to diagnose and treat bone illnesses. Some examples of the usage of x-ray images are as follows:

- **Fracture diagnosis and treatment:** X-ray pix are most frequently used in fracture prognosis seeing that it's the fastest and easiest means for the doctors to be taught the accidents of bones and joints. Doctors regularly use x-ray snap shots to verify whether a fracture exists, and the place of the fracture. Within the recovery procedure, medical professionals additionally use x-ray graphics to assess whether or not the injured bones and joints have recovered.

- **Evaluation of skeletal maturation:** X-ray images are used to investigate the physiological age and development talents, and to predict grownup stature.

- **Bone densitometry:** Bone densitometry measures the calcium content in the bones. Almost always, people with bone mineral densities drastically curb than the common level usually tend to smash a bone. Bone densitometry does not indicate whether or not bone fractures exist or now not, however can predict the risk of fracture incidence.

- **Hip replacement:** Hip substitute is a scientific procedure in which the hip join t is replaced with a metallic implant, and the hip socket is changed with a plastic or a metallic and plastic cup. Hip substitute surgical procedure requires x-ray pictures of the hip.

Figure 1.1: Hip replacement. The patient's right hip (on the left in the photograph) has been replaced by a metal implant.

In all of the medical functions highlighted above, segmentation of bones in x-ray portraits is an predominant step in computer-aided prognosis, surgical procedure and therapy.

There are three basic techniques for medical snapshot segmentation, namely, manual segmentation, semi-computerized segmentation and automatic segmentation. All of them have their professionals and cons. Manual segmentation through domain specialists is probably the most accurate however time-ingesting. Semi-automated segmentation requires the person to furnish a small quantity of inputs to facilitate accurate segmentation. Automated segmentation does not require any consumer input and, accordingly, is rather more complex to receive accurate results. However, in lots of purposes that contain a colossal quantity of graphics, it's the simplest nearly viable method. Thus, the major center of attention of this research is on computerized segmentation.

II. PROBLEM ANALYSIS

In order to study the problem of bone segmentation in x-ray images, some characteristics of this problem are analyzed.

- unlike different medical imaging modalities, bone areas in x-ray pictures probably overlap with different organs, such as flesh, gentle tissues and other bones. Pelvis vicinity in x-ray graphics can also be “corrupted” by using fuel inside the ascending and descending colons or bowel.
- Bones are related with different bones by means of joints. When the whole bone constitution is being segmented, articulation of the bones wishes to be regarded.
- Bones are three-D in nature. A easy 2-D closed curve may not be accurate enough to symbolize the boundaries of bones in x-ray pictures. F or illustration, the pelvis bone could have got to be represented by means of its outer boundaries as good as interior contours.

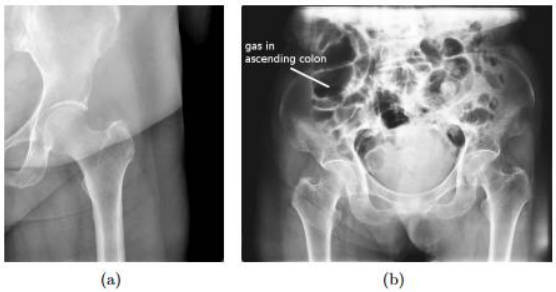

Figure 3.1: Characteristics of x-ray images. (a) Bone regions in x-ray images often overlap with other organs, such as flesh, soft tissues and other bones. (b) Pelvis region is corrupted by gas in the ascending and descending colons.

Segmentation of bone buildings in x-ray pictures is both intrinsically and extrinsically complicated. Intrinsic difficulties refer to those brought about through the intrinsic homes of x-ray imaging programs:

- **Noise:** Noise in x-ray pics has a quantity of origins, but the most important is from the x-ray supply itself. This kind of noise is known as “quantum noise”, in reference to the discrete nature of the x-ray photons producing it.
- **Overlapping:** As discussed within the characteristics of the main issue.

Extrinsic difficulties are usually due to the patients:

- **Ambiguity:** Neighboring tissues inside of human body could have equivalent x-ray absorption rates. As a result, the boundaries of the organs is also ambiguous. That's, within the snapshot, there may be many times no clear part between two neighboring organs.

Bone density variability: Distinct patients can have extraordinary bone densities, which outcomes in significantly distinctive intensities within the bone regions between their x-ray pix. A traditional sufferer traditionally has dense bones and the x-ray picture of bones is vibrant, whereas a patient who suffers from osteoporosis has lo w-density bones, which results in a lot darker bone portraits. Additionally, other physique tissues may also impact the intensities of bone images.

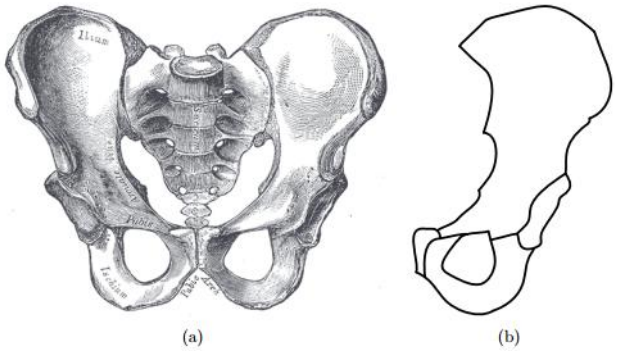

Figure 3.2: Representation of the pelvis bone.(a) 3-D pelvis bone. (b) 2-D contour representation of the left pelvis bone.

- **Inter-sufferer form variability:** The shapes of the bones of specific patients can differ relatively significantly. In special, the shape of the pelvis bone of a female patient is relatively different from that of a male patient. That is considering that females more commonly have so much wider pelvis bones.
- **Imaging pose variability**: The bones could also be placed in exclusive materials of different images due to one-of-a-kind imaging pose.

III. MEDICAL IMAGE SEGMENTATION TECHNIQUES

Common scientific image segmentation approaches may also be classified into the next classes: classical photo segmentation ways (Thresholding, regions-based, and edges-headquartered), sample realization-headquartered, deformable models, wavelets-headquartered approaches, and atlas-situated strategies. To exemplify probably the most segmentation process, we can take into account a real X-ray photograph shown in Fig. 1.

Figure 1. An X-ray image test.

A. Classical image segmentation methods

Classical methods include the following segmentation techniques: Thresholding, region-based, and edge-based methods.

Thresholding is without doubt one of the simplest segmentation procedures and involves thresholding the picture intensity. There are two classes of thresholding ways: international methods and adaptive ways. Within the case of global thresholding, only one threshold

is chosen for the complete photo, whilst within the case of adaptive thresholding, the local thresholds are selected independently for each and every pixel (businesses of pixels).

Global methods are headquartered on the fact that the snapshot has a bimodal histogram. The article of curiosity can also be separated from the heritage by means of comparing the depth of each pixel within the photograph with a threshold. Some pixels, whose depth values are greater than the edge, are categorised as being a part of workforce A- object of interest(with an intensity worth of 1), and the leisure of the pixels as being a part of workforce B-heritage(with an intensity worth of 0.

Adaptive ways are situated on the fact that a given image is split right into a sequence of sub-pics and, for every sub image, some thresholds are computed. Yet another process, known as regional adaptive Thresholding, consists in analyzing the snapshot intensities around every pixel and making a choice on an character threshold for each pixel, taking in consideration the measure of the intensity values in its local neighborhood.

World approaches are simple and speedy, however are suitable just for pictures with bimodal intensity distribution (likelihood distribution with two exclusive modes). Yet another component that affects the efficiency of Thresholding is the unequal illumination in the snapshot. Moreover, global methods should not priceless for multichannel pix, considering the fact that only two lessons are generated.

Adaptive ways are more tricky than international approaches, related to computations. Nevertheless, these ways can also be successfully used for extracting small areas or objects from a variable heritage. The adaptive threshold established segmentation operation is used for the scan snapshot in Fig. 1 and the outcome is provided in Fig. 2. Examining the resulted photograph in Fig. 2, we will see that no longer handiest the bones are highlighted, but additionally materials of the flesh. Additionally, the bones of the arm are usually not separated.

An software of thresholding founded segmentation is discovered in digital mammography, with two courses of tissues, healthy and tumorous. This easy operation can be highly powerful, also in Computerized Tomography (CT), the place the pixel worth has actual-world importance. However, many of the scientific graphics would not have bimodal distribution of intensity. For that reason, thresholding algorithms are hardly ever utilized in medical imaging.

Region-founded approaches have the cause of grouping pixels having similar intensities. The fundamental area-based segmentation algorithms are: region-growing segmentation, and watershed algorithms.

Region-developing algorithm is a simple pixel-headquartered photograph segmentation procedure, which includes the determination of pixels (the seeds), and then developing areas round these seeds, using a homogeneity standards. If the becoming a member of pixels have an identical picture elements because the seed, they're built-in into the region. A statistical test is quite often used to take the selection.

Figure 2. X-ray image segmentation using thresholding.

The alternative of homogeneity criterion is critical for the success of the algorithm. Some examples of homogeneity criterions are: the difference between the depth of the pixel and the region mean depth, or the weighted sum of gradient expertise and the contrast between the region and the pixel. The procedure is iterated on, within the same manner as normal knowledge clustering algorithms, except a predefined termination situation is reached.

An expertise is that vicinity growing algorithms are quick and may participate in correct segmentations of areas that have the identical elements however are spatially separated. Nevertheless, they are sensitive to noises and hence may just produce undesired segments, regions with holes or disconnected areas. Additionally, the seed point is bought utilizing manual interplay.
Watershed process(watershed develop into) is yet another vicinity-established procedure. This procedure is situated on the grayscale mathematical morphology and it is used for multi element photos. Intuitively, the watershed algorithm may also be concept of as a panorama that's flooded with the aid of water. The peak of the landscape at every point represents the pixel's depth. The watershed grow to be computes the picture regions which symbolize the basins and neighborhood boundaries (the ridgelines). The image gradient is used as input of the turn into, such that the basin limits are founded at excessive gradient points.
This kind of segmentation process is inconspicuous and intuitive and has good houses, which make it useful for many photo segmentation purposes. However, it has a number of essential dangers such as: over-segmentation, sensitivity to noise, and it's bad at detecting thin buildings and structures with low sign-to-noise ratio.
The bones segmentation via region developing tactics is received in, in the case of hand-wrist radiographs.

Side - founded segmentation methods use edge detectors to search out edges in the photograph. Facet detection has an essential position in photo processing and computer imaginative and prescient, especially in characteristic detection and extraction domain. Edges can also be seen as image facets, where the luminous depth of the photograph alterations noticeably along a distinctive orientation. If the intensity of the photos has a powerful trade, and then there is a excessive likelihood for an area at that photo role [9]. The classical operators for edge detection are the next: Prewitt, Sobel, Roberts and Laplacian of Gaussian (LoG) operator. Most classical area detectors are established on the neighborhood gradient (the first order derivatives) of the photograph operate. Virtually, the change between these operators is that they use special types of filters for estimating the gradient accessories and one other approach for combining these add-ons. An illustration of X-ray snapshot segmentation making use of Sobel is provided in Fig. 3. On this case the contour of the hand's skeleton just isn't perfectly detected, some discontinuities at the top of the fingers' bones can be located. Furthermore, no longer best the palms' skeleton is detected, but in addition contours of the hand/arm, which may also be discovered on the backside of the image in Fig. 3.

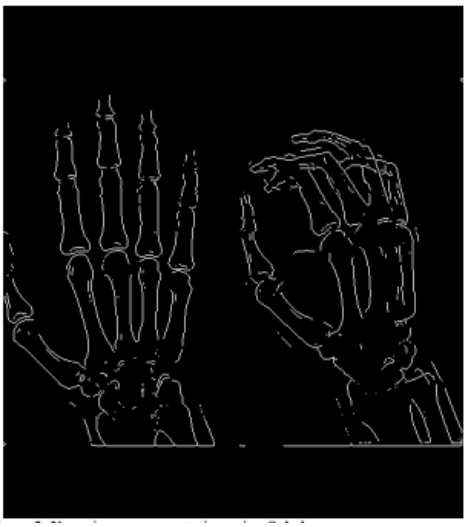

Figure 3. X-ray image segmentation using Sobel.

Roberts(Roberts' pass operator) is among the oldest facet detectors. It is a simple operator that approximates the snapshot gradient alongside the horizontal and the vertical instructional materials, using discrete differentiation and emphasizes regions comparable to edges (regions with a excessive spatial frequency). The intent of the next step, called non-maximum suppression, is to preserve most effective part-pixels, in the snapshot of the gradient magnitudes; the place the gradient has regional maxima. In the end, the last step implies thresholding with hysteresis. Two thresholds are used, T1 and T2 and, in the end, the pixels are separated into side pixels or a non-side pixels. An example of X-ray segmentation using canny facet detector is offered in Fig. 4.

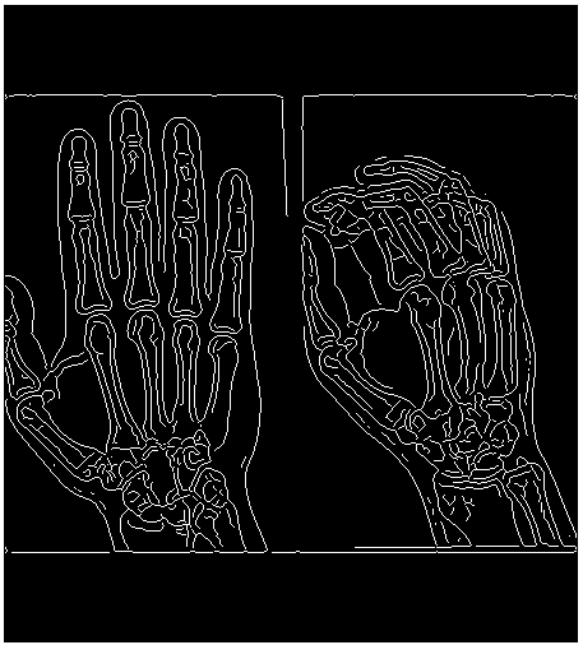

Figure 4. X-ray image segmentation using Canny edge detector.

The disadvantage of edge-headquartered segmentation algorithms is that they're touchy to noise and tend to find edges which can be inappropriate to the actual boundary of the article. For illustration, in Fig. Four are detected two area boundaries, some of the flesh and one for the bone. But, almost always, only the bone wishes to be separated. A further predicament that could appear is that the extracted edges could be disjoint and cannot wholly represent the boundary of an object. This sort of case is shown in Fig. 2. Hence, some additional processing is needed to connect them to kind closed and linked object regions.

Side detection (together with Sobel, Prewitt, Roberts or Canny detectors) used to be utilized in. In a pc based computerized tool used for the prognosis in prosthesed hip has been proposed. One step in the algorithm is the bone and prosthesis segmentation, which is used to supply medical primary measurements. The quality results for deciding on the prosthesis were discovered utilising Expectation-Maximization algorithm and Canny.

1. Pattern recognition-based

Segmentation implies pixels classification, so it's often handled as a sample cognizance hindrance. Sample attention strategies incorporate unsupervised methods (clustering) and supervised approaches (classification).

Clustering or cluster analysis is an unmanaged method and refers to a class of algorithms largely used for picture segmentation. It's a process for grouping a suite of objects into corporations (clusters), in order that similar objects belong to the same cluster, at the same time distinct object belong to exceptional clusters. Quite a lot of clustering algorithms have been proposed within the literature. Between them we point out: the ok-manner algorithm, the fuzzy c-way algorithm, hierarchical clustering or the Gaussian mixture procedure.

A detailed algorithm that can be incorporated in this category is the mean-shift algorithm. It was once offered in and searches modes or local maxima of the density function within the elements house, defining the clusters. X-ray segmentation utilizing the imply-shift algorithm is proven in Fig.5.

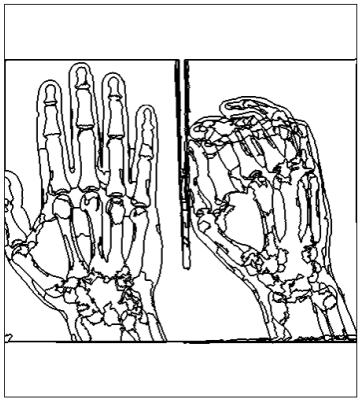

Figure 5. X-ray image segmentation using mean-shift algorithm.

Clustering strategies are effective ways seeing that they're correct for multi-band snap shots, for instance colour graphics or far flung sensing images. The drawback of cluster analysis is the fact that the quantity of clusters must be a priori set. Fuzzy clustering headquartered on fuzzy c-method algorithm was used for segmentation in. The authors present a brand new object based segmentation utilizing fuzzy clustering algorithm for an X-ray photograph having two objects (femur and tibia).

Classification-based segmentation techniques are supervised approaches. They require a training segment, in which the training knowledge is manually segmented. Situated on the training section outcome, the scan information is automatically segmented. A couple of classification approaches are described in the literature. They may be able to be classified in: nonparametric classifiers (the nearest-neighbor classifier, the k-nearest neighbor classifier, the Parzen window) and parametric classifiers (the highest likelihood and Bayes classifier). In the case of the nearest-neighbor classifier, the pixels belonging to the test knowledge are labeled in the same classification as the pixels with the closest intensity from the educational data. The ok-nearest-neighbor (kNN) classifier is the generalized nearest-neighbor classifier. In this case, every pixel is categorised in essentially the most appropriate class amongst its nearest neighbors due to the fact that the weighted majority of its neighbors' votes. Parzen home windows may also be viewed because the generalized kNN algorithm. The algorithm considers all pixels in the voting scheme and assigns their weight using a kernel perform. Parametric classifiers anticipate a likelihood distribution of information.
The drawback of classification algorithms is the dearth of spatial modeling. This trouble is raised, when photographs corrupted with the aid of depth in homogeneities ought to be segmented. The accuracy of this algorithm generally depends upon the selected training samples.
Classification-situated tactics had been used in the place an adaptive fuzzy system used to be used for lateral skull segmentation. Nonetheless, classification-founded algorithms are most likely now not strong for X-ray image segmentation, due to the intrinsic properties of X-ray snap shots and likewise considering X-rays are affected by noise and may just produce over segmentation.

2. Knowledge-based techniques

An additional category of segmentation approaches is knowledge based. The algorithm is meant to be expert making use of some domain targeted principles, and the great method of representing them is ontology-situated. The authors proposed an application to examine thoracic constructions established on ontologies. The method consists of a few hierarchies, in particular supposed for image segmentation: radiograph entity, features and landmarks. The ontology is founded on radiography entities. The authors of proposed a knowledge-founded technique for analyzing and segmenting lung boundaries in chest X-rays. The procedure is situated each on skills derived from each model and photograph, with the purpose of spatially constraining the extraction of a given anatomical structure. The authors proposed modeling ways for typical and pathological changes in the anatomy. The Canny operator is applied the at a couple of resolutions.

IV. RELATED WORK

Badri Narayan Subudhi, Ishan Patwa et. al (2015) Many image segmentation techniques are available in the literature. One of the most popular techniques is region growing. Research on region growing; however, has focused primarily on the design of feature extraction and on growing and merging criterion. Most of these methods have an inherent dependence on the order in which the points and regions are examined. This weakness implies that a desired segmented result is sensitive to the selection of the initial growing points and prone to over-segmentation. In this paper, we have proposed an edge preserving region growing technique for segmentation of aerial images. The proposed scheme is demonstrated by segmentation of two-color aerial image segmentation. The results obtained by the proposed scheme are found to be good. The accuracy of the proposed scheme is evaluated by comparing the results obtained by it with those of the conventional region growing, mean-shift, and spatio-contextual MRF-based segmentation techniques, and results are found to be better.

Shiyong Ji, Benzheng Wei et. al (2014) In this paper, the medical image segmentation is the key approach of image processing for brainMRI images. However, due to the visual complex appearance of image structures and the imaging characteristic, it is still challenging to automatically segment brain MRI image. A new multi-stage segmentation method based on super pixel and fuzzy clustering (MSFCM) is proposed to achieve the good brain MRI segmentation results. The MSFCM utilizes the super pixels as the clustering objects instead of pixels, and it can increase the clustering granularity and overcome the influence of noise and bias effectively. In the first stage, the MRI image is parsed into several atomic areas, namely, super pixels, and a further parsing step is adopted for the areas with bigger gray variance over setting threshold. In this paper, the MSFCM algorithm is presented to segment the brain MRI image, which consists of the super pixel method and the FCM algorithm. The image was firstly parsed into several

super pixels, and then deep segmentation is to be done for the areas with bigger gray variance than setting threshold. And to get the fuzzy membership of each super pixel, the FCM algorithm is used to cluster the super pixels rather than pixels, and the membership is used to determine the classification for these super pixels.

ChuanLong Li, Ying Li et. al (2012) In this paper, the fuzzy c-means (FCM) algorithm is one of the most widely used method for data clustering, the standard FCM is not effective by itself to segment the image, as it fails to deal with the significant property of images, such as noise and intensity in homogeneity. In this paper, we propose a novel fuzzy c-means image segmentation algorithm. Its effectiveness is due to two mechanisms. The first mechanism is the replacement of the Euclidean distance traditionally used to measure similarity of the image pixels by a novel similarity measure which is considered spatial neighborhoods using Gaussian kernel, and thus our method becomes less sensitive to the noise of the image. The second mechanism is not requirement of any similarity penalty term in FCM's objective function as some FCM's variants to reduce the influence of noise on the result of image segmentation, in addition, our method needs no requirement of setting parameter according to the image, and thus our method is more general and robust for image segmentation.

Yongzheng Geng, Jian Chen et. al (2013) In this paper, image segmentation is the first step in computer vision project. But it is also the key procedure from image processing to image analysis. With the continuous development of computer hardware and technology advances, more attention has been paid to the color image. Based on previous image segmentation technology, this paper proposes a novel color image segmentation method. The method improves the JSEG (Joint Systems Engineering Group) algorithm, and it uses the results of JSEG as the input of Ncut (Normalized Cuts). This paper combines the JSEG algorithm and the graph theory to propose a novel color image segmentation algorithm, namely J-Cut algorithm. This method is simple, effective and easy to understand. This algorithm is effective for improving the complex iterative process of the JSEG and reduces its complexity. In addition the region merging is more accurate and more consistent with subjective human visual perception.

Sushovan Mandal et. al (2010) In this paper, a robust segmentation technique is presented in this dissertation, integrating the merits of dissimilarity matrix for brain MR image segmentation. It can segment objects from medical images such as MRI. The development of tools for automated detection of brain tumor is considered quite important in the field of clinical research and biomedical research in general. MR image segmentation is an important but inherently difficult problem in medical image processing. In general, it cannot be solved using straightforward, conventional image processing techniques. Due to the characteristics of MR images, development of automated algorithms is challenging. There is a significant inter-patient variation of signal intensities for one same tissue type because of partial volume effect, inherent noise and wide range of imaging parameters, which affect the tissue intensities.

Eleftheria A. Mylona, Michalis A. Savelonas et. al (2014) In this paper, medical doctors are typically required to segment medical images by means of computational tools, which suffer from parameters that are empirically selected through a cumbersome and time-consuming process. This chapter presents a framework for automated parameterization of region-based active contour regularization and data fidelity terms, which aims to relieve medical doctors from this process, as well as to enhance objectivity and reproducibility. Leaned on an observed isomorphism between the eigenvalues of structure tensors and active contour parameters, the presented framework automatically adjusts active contour parameters so as to reflect the orientation coherence in edge regions by means of the "orientation entropy."In this chapter, a framework for automated adjustment of active contour regularization and data fidelity parameters is presented and applied for medical image segmentation. The presented framework is inspired from the properties of structure tensors. The latter are appropriate descriptors of the orientation coherence of edge regions. This information is accordingly incorporated into the active contour parameters by means of OE. In this light, region-based forces are boosted on non-target, unstructured regions, driving the contour away and guiding it towards the target, structured ones.

Songcan Chen and Daoqiang Zhang et. al (2004) In this paper, Fuzzy c-means clustering (FCM) with spatial constraints (FCM_S) is an effective algorithm suitable for image segmentation. Its effectiveness contributes not only to the introduction of fuzziness for belongingness of each pixel but also to exploitation of spatial contextual information. Although the contextual information can raise its insensitivity to noise to some extent, FCM_S still lacks enough robustness to noise and outliers and is not suitable for revealing non-Euclidean structure of the input data due to the use of Euclidean distance (L_2 norm). The well-known "kernel methods "has been recently applied to unsupervised clustering.

Tobias Heimann , Hans-Peter Meinzer et. al (2009) In this paper, statistical shape models (SSMs) have by now been firmly established as a robust tool for segmentation of medical images. While 2D models have been in use since the early 1990s, wide-spread utilization of three-dimensional models appeared only in recent years, primarily made possible by breakthroughs in automatic

detection of shape correspondences. In this article, we review the techniques required to create and employ these 3D SSMs. While we concentrate on landmark-based shape representations and thoroughly examine the most popular variants of Active Shape and Active Appearance models, we also describe several alternative approaches to statistical shape modeling. Structured into the topics of shape representation, model construction, shape correspondence, local appearance models and search algorithms, we present an overview of the current state of the art in the field. We conclude with a survey of applications in the medical field and a discussion of future developments.

Shweta Jena, Barnali Sahu et. al (2015) In this paper, image enhancement is the preprocessing stage of the image processing. The objective is to improve the visual effects and the perception of knowledge in images for viewers and to provide a better input for automated image processing technique. It gives emphasis on the whole or part features of the graphics in the designated image applications to enlarge the objects in the graphics. The enhanced image by use of threshold segmentation method identifies bone fracture in medical X-ray images. In this paper, the effectiveness of the simple Thresholding techniques at different levels, multiple Thresholding, and optimal Thresholding are compared to medical images.

V. CONCLUSIONS

In this paper we described a series of tactics that have been published within the contemporary literature, concerning clinical pics segmentation. We furnished an overview regarding the implementation of every segmentation process, highlighting advantages and downsides. The analysis of those segmentation techniques can also be done, in terms of: performance, sensitivity to noise, computational complexity, or the necessity of coaching phase. Probably the most correct approaches are probably the trickiest and time consuming. We realized the classification opening with the most simple and rapid methods and we increased the computational complexity and the processing time with each offered process. Thresholding is likely one of the most straightforward segmentation tactics. The disadvantage of Thresholding ways is that they are able to be applied to a single-band picture, akin to a gray-scale image or a single band of a multi-band photograph.

Area situated ways have shown to be very useful and effective segmentation tactics in picture processing. However they have got over-segmentation tendency, require handbook initialization and are sensitive to noise. Fuzzy clustering algorithms are among the most robust algorithms used for optimization. Not too long ago, FCM have tested efficiency in handling computationally tricky problems.

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