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# Concentration on the Area of Significance in Medical Images

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**ABSTRACT**
In this project, our goal is to detect objects in medical images whose boundaries may or may not be distinctly defined. In the problem definition evolving the active contour, would stop on the desired boundary. For efficient object detection, we extract the texture and shape of medical images automatically using edge detection which is widely used in image segmentation. The active contour reaching the desired boundary i.e., the stopping condition does not depend on the gradient of the image, but is instead related to a particular segmentation of the image. Also, the initial curve can be anywhere in the image, and interior contours are automatically detected. Medical images plat a very important role in detection of tumors, illnesses and abnormalities, due to the swift expansion in digital medical images; a need has risen for efficient algorithms to detect a region of interest in medical images. Such a system would provide great assistance to doctors in medical diagnosis.
**Keywords: -** Area of significance, medical images, segmentation, automatic detection

## I. INTRODUCTION

Image segmentation is a fundamental task in image analysis that is responsible for partitioning an image into many different sub-regions based on a desired feature. One of the most widely used image segmentation methods is using Active Contours as they always produce sub-regions with continuous boundaries, whereas the kernel-based edge detection methods often produce boundaries that are discontinuous. To make the process of implementation of active contours more flexible and convenient, level set theory is used. Traditional edge-based active contour models, however, have been applicable only to relatively simple images whose sub-regions have no internal edges and are uniform.

Partitioning an image based on image intensity statistics measured within sub-regions provides a partial solution to the problem of internal edges.

Although representing an image as a piecewise constant produces better results than traditional edge-based methods, the performances of such methods is still poor on images with multiple components each of whom have sub-regions, e.g. a complex medical image of human bones. The segmentation of such multispectral images is even a more challenging problem. The goal of our work is to develop segmentation methods which provide robust performance on such medical images with non-uniform sub-regions.

The active contour models that we propose show robust segmentation performance on multispectral medical images

Whereas the efficiency of traditional segmentation lags in the same images.
Also, the proposed methods provide a means of automatic pattern classification by integrating image segmentation and statistical pattern classification. This autonomous classification would assist in efficient medical diagnosis. In the proposed system we are using three algorithms, namely:

1. Active Contour without Edges
2. Localized Region Based Active Contours
3. Level Set Evolution

Some applications of our project are locate tumors and other malignant tissues, measure tissue volumes, diagnosis, study of anatomical structure, surgery planning, virtual surgery simulation, intra-surgery navigation etc.

## II. NOISE

Image noise is generally characterized by random variations in the brightness or color information in an image. The image brightness should be uniform except where it forms a part of the image. The image quality is reduced and this is a problem especially where the objects imaged are relatively minute or have low contrast. This noise might be produced by the sensors and circuits in different imaging equipment.

Image noise is dangerous in medical images as it may lead to wrong diagnosis of a patient. All medical images contain noise resulting in a grainy appearance of the image. Every imaging method incurs some sort of distortions in form of noise, but noise can be more prevalent in some of the imaging techniques.

### A. Types of Noise:

***1. Uniform Noise (Quantization Noise) [2]***
In uniform noise, the levels of the gray values of noise are uniformly distributed across a specified range. Uniform noise caused by fixing the pixels of an image to a number of distinct levels is called quantization noise. It has a uniform distribution. It is usually used to degrade images for testing purposes.

***2. Gaussian Noise (Amplifier Noise) [2]***
This noise has a probability density function of the normal distribution. It results from a contribution of many

different signals and is the most common type of noise. This noise model is additive nature meaning that each of the pixels in a noisy image is the sum of an original pixel value and random noise value.

***3. Impulse Noise (Salt-and-pepper Noise) [2]***

Black and white dots appear in the image giving a blurry appearance to the image. It arises due to sharp and sudden changes in image signal. Overheated image capturing components and dust particles in the image acquisition source cause this type of noise. There are only two possible values that exist each with a probability of less than 0.2. It also known as shot noise and is usually caused by malfunctioning pixel elements in camera or timing errors in digitization of images.

***4. Poisson Noise (Photon Noise) [4]***

It is caused when the number of photons a sensor detects is not enough to gather statistical information about the image. It is prevalent where an image is created by accumulation of photons on a detector. Typical examples are X-Ray films, CCD cameras, etc.

X-ray photons impinge on a surface, such as an image receptor, in a random pattern. No force can cause them to be evenly distributed over the surface. One area of the receptor surface might receive more photons than another area, even when both are exposed to the same average x-ray intensity. In all imaging procedures using x-ray or gamma photons, most of the image noise is produced by the random manner in which the photons are distributed within the image [1].

***5. Film grain***

Photographic film has the grain of a signal-dependent noise that is similar to the statistical distribution to shot noise. Film grain is usually regarded as a nearly isotropic (non-oriented) noise source [3].

## III. MEDICAL IMAGING

Medical imaging creates visual representations of the interior of a body that are helpful in medical analysis.

The main function of medical images is to reveal structures hidden from plain sight that might be causing trouble due to abnormal functioning or behavior. It can also be used as a database for expected anatomies so that we can identify malfunctioning of structures.

### A. Types of Medical Imaging

***1. Radiography [6]***

Projection radiography and fluoroscopy are the types of radio graphic images used for medical imaging. They are widely used and preferred despite of better technologies being available due to their low cost, better resolution and lower doses of radiation.

***2. Magnetic Resonance Imaging (MRI) [6]***

Hydrogen nuclei consisting of a single proton present in the water molecules found in human tissues are excited using extremely powerful magnets present in the MRI scanner. This produces a signal which on detection results in the image of the tissue.

***3. Ultrasound [5]***

Ultrasound uses ultrasonic energy that is, sound energy beyond the range of human interception, to create images of internal organs. Ultrasonic waves are released into the body via an interface. When it is incident on two different tissues, an echo is generated that can captured and processed to generate an image of the reflecting structure.

***4. Endoscopy [5]***

This technique of medical imaging involves the simple mechanism of inserting a minute camera along with an optical fiber inside narrow areas in the human body which cannot be examined from the surface. The endoscope is made up of two fiber bundles, one to illuminate inner structure of object and the other to gather light reflected from the structure.

***5. Computed Tomography [5]***

Tomography is the method of imaging a single plane of an object. X-Rays are used in this technique commonly known as CT scans. The rays are passed through the body. The received rays contain the information about the constituents in their path. The calculations pertaining to the intersections of the rays with different body parts are pretty complex and hence a computer is required, so the name.

## IV. SEGMENTATION AND TYPES

Image segmentation performs the task independently partitioning an image into different regions that are meaningful in a certain way. Image segmentation is a useful tool in many realms including industry, health care, astronomy, and various other fields [7]. We can very easily tell what is contained in a picture based on our region of interest. But for a computer it is not easy and so many questions need to be answered before reaching a decision.

Discontinuity and similarity/homogeneity are two basic properties of the pixels in relation to their local neighborhood used in many segmentation methods [7].

***A. Thresholding Method [7]***

An input image is partitioned into pixels depending upon whether it matches the thresholding criteria.

***B. Edge Based Methods [7]***

Edge based segmentation is the location of pixels in the image that correspond to the boundaries of the objects seen in the image. It is then assumed that since it is a boundary of a region or an object then it is closed and that the number of objects of interest is equal to the number of boundaries in an image.

### *C. Region Based Methods [7]*

Similarity criteria are used to segment an image into different regions by applying the criteria to a set of pixels. All the pixels share at least some common characteristics.

- An initial set of small areas are iteratively merged according to similarity constraints.
- Start by choosing an arbitrary seed pixel and compare it with neighboring pixels.
- Region is grown from the seed pixel by adding in neighboring pixels that are similar, increasing the size of the region.
- When the growth of one region stops we simply choose another seed pixel which does not yet belong to any region and start again.
- This whole process is continued until all pixels belong to some region.

## V. ALGORITHMS

### *a. Active Contour Model*

The concept of active contours was introduced by Kass, Witkin and Terzopoulos. Active contours are mainly used in the domain of image processing to dynamically locate the outline of an object. It may often happen that the edges in an image are not continuous, i.e. there might be holes along the edges, and spurious edges can be present because of noise. Active contours try to improve such images by adding desirable properties such as continuity and smoothness to the contours of objects in the image. An active contour is modeled as parametric curve that aims to minimize its internal energy by moving into a local minimum.

The position of the snake is given by the parametric curve v(s) = [x(s); y(s)]T with s [0; 1], in practice the curve is often closed which means that v(0) = v(1). Furthermore the curve is assumed to be parameterized by arc length. A closed parametric snake curve is illustrated in Figure 1.

Each point along the parametric curve is under the influence of both internal forces and external forces, and the contour continuously tries to position itself in such a manner so that the combined energy of both these forces is minimized and the active contour moves to a local minimum.

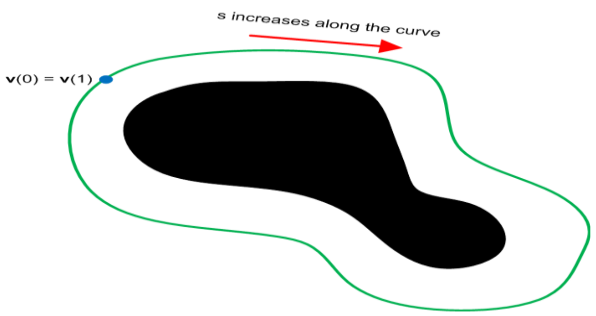


Figure 1: Illustration of a parametric snake curve v(s). The blue dot marks the starting point and end point of the snake curve. Ideally the snake will have minimized its energy when it has positioned itself on the contour of the object.

### *b. Localized Region Based Methods [7]*

We begin the local region-based method by initialising pixels in the narrow band. Every pixel is initialised with the local interior and exterior statistics. Whenever a narrow band moves, it includes an uninitialized pixel that has an additional cost. The new pixel's local statistics need to be initialised then. The position of the contour from the final destination determines the number of initialisation operations required and this process is performed only once for every pixel.

When a pixel is crossed by a moving contour moving it from an exterior region to an interior region or vice versa, that is when updating occurs. The statistical models of the neighbourhood pixels are then correspondingly updated. Each pixel maintains a record of the number of pixels in the local inside and outside regions and along with that, a sum of intensities of pixels in these regions.

Global region models do not define how segmentation takes place here. Smaller local regions are used to define foreground and background regions. Therefore removing the assumptions that these can only be represented with global statistics.

Let I denote a given image defined on the domain Ω, and let C be a closed contour represented as the zero level set of a signed distance function φ, i.e., C = {x|φ(x) = 0}. The interior of C is specified by the following approximation of the smoothed Heaviside function: [12]

$$\mathcal{H}\varphi(x)=\begin{cases} 1, & \varphi(x)<-\varepsilon \\ 0, & \varphi(x)>\varepsilon \\ \frac{1}{2}\left\{1+\frac{\varphi}{\varepsilon}+\frac{1}{\pi}\sin\left(\frac{\pi\varphi(x)}{\varepsilon}\right)\right\}, & \text{otherwise.} \end{cases}$$

Similarly, the exterior of C is defined as (1 − Hφ(x). To specify the area just around the curve, the derivative of Hφ(x), a smoothed version of the Dirac delta is used: [12]

$$\delta\varphi(x)=\begin{cases} 1, & \varphi(x)=0 \\ 0, & |\varphi(x)|<\varepsilon \\ \frac{1}{2\varepsilon}\left\{1+\cos\left(\frac{\pi\varphi(x)}{\varepsilon}\right)\right\}, & \text{otherwise.} \end{cases}$$

A second spatial variable y is introduced.x and y are used as independent spatial variables each representing a single point in Ω. Using this notation, a characteristic function in terms of a radius parameter r is introduced as [12]

$$\mathcal{B}(x,y)=\begin{cases} 1, & \|x-y\|<r \\ 0, & \text{otherwise.} \end{cases}$$

B(x, y) is used to mask local regions. This function will be 1 when the point y is within a ball of radius r centred at x, and 0 otherwise. Using B(x, y), energy functional in terms of a generic force function, F is given as follows: [12]

$$E(\varphi)=\int_{\Omega_x}\delta\varphi(x)\int_{\Omega_y}\mathcal{B}(x,y)\cdot F(I(y),\varphi(y))\,dy\,dx.$$

The function, F is a generic internal energy measure used to represent local adherence to a given model at each point along the contour. In computing E, only contributions from the points near the contour are considered.

Finally, in order to keep the curve smooth, a regularisation term is added as is commonly done. The arc length of the curve is penalised and this penalty is weighted by a parameter λ. The final energy is given as follows: [12]

$$E(\varphi)=\int_{\Omega_x}\delta\varphi(x)\int_{\Omega_y}\mathcal{B}(x,y)\cdot F(I(y),\varphi(y))dydx$$
$$+\lambda\int_{\Omega_x}\delta\varphi(x)\left\|\nabla\varphi(x)\right\|dx.$$

*c. Level set Method*

Level set methods are a conceptual framework for using level sets as a tool for numerical analysis of surfaces and shapes. The advantage of the level set model is that one can perform numerical computations involving curves and surfaces on a fixed Cartesian grid without having to parameterize these objects [8]. Also, the level set method makes it very easy to follow shapes that change topology, for example when a shape splits in two, develops holes, or the reverse of these operations. All these make the level set method a great tool for modelling time-varying objects, like inflation of an airbag, or a drop of oil floating in water. [9]

Level set methods were first introduced by Osher and Sethian for capturing moving fronts. Active contours were introduced by Kass, Witkins, and Terzopoulos for segmenting objects in images using dynamic curves. [10]

Traditional Level Set Methods:

In level set formulation of moving fronts (or active con- tours), the fronts, denoted by C, are represented by the zero level set C(t) = {(x, y) | φ(t, x, y) = 0} of a level set func- tion φ(t, x, y). The evolution equation of the level set func- tion φ can be written in the following general form:

$$\frac{\partial\phi}{\partial t}+F|\nabla\phi|=0$$

which is called level set equation The function F is called the speed function. For image segmentation, the function F depends on the image data and the level set function φ.

In traditional level set methods, the level set function φ can develop shocks, very sharp and/or flat shape during the evolution, which makes further computation highly inaccurate. To avoid these problems, a common numerical scheme is to initialize the function φ as a signed distance function before the evolution, and then "reshape" (or "re-initialize") the function φ to be a signed distance function periodically during the evolution.

## VI. RESEARCH CHALLENGES

Identification of the region of interest in medical images by a computer is a very difficult task for the machine unlike us who can intuitively identify areas to focus ourselves on. Computers need to be told where to start from and how to identify the human body structure or abnormality from the rest of the medical image.

Software used for the task requires heavy computing and hence drains a lot of memory from the machine. Increasing the number of iterations to narrow down the focus and get the exact intended area may not be the best option as it takes a toll on the machine's resources. As a result, faster machines are required to effectively run the detection software. Understanding the complex mathematical equations is also very tedious since they include concepts not covered by a superficial understanding of the subject, and that implementing it on a machines makes it even more difficult.

All the algorithms studied here in the paper are not the only ones available, but are studied due to their widespread acceptance. Other less known algorithms may work perfectly for particular medical images, and need to be tested. Other challenges include obtaining a database of medical images containing all types of images in good numbers to test the algorithms on since most of them are not legally available.

## VII. CONCLUSION

Hence, here we present a review of types of noises, medical images, segmentation methods and algorithms to be dealt with while using a machine to concentrate on areas of significance in medical images without a professional interference.

Algorithms reviewed do not completely satisfy our need to effectively segment images so as to separate out the body structures or abnormalities, but they work for some images with some noise present and that a combination of them or different algorithms need to be used for images that cannot be segmented by them alone.

Further study of the intricate details of the working of these algorithms may reveal some insights to optimizing their performance which is precisely our goal. A consensus needs to be reached regarding which algorithms should be used for which images and for how long and that is there a possibility of using just one algorithm by varying certain parameters for a majority of images.

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