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Comparison of Various Image Edge Detection Techniques for Brain Tumor Detection

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ABSTRACT

Brain tumors are created by abnormal and uncontrolled cell division in brain itself. If the growth becomes more than 50%, then the patient is not able to recover. So the detection of brain tumor needs to be fast and accurate. In this paper the comparative analysis of various Image Edge Detection techniques is presented. The experiment is conducted using MATLAB 7.0. It has been shown that the Canny's edge detection algorithm performs better than all these operators under almost all scenarios. Evaluation of the images showed that under noisy conditions Canny, LoG(Laplacian of Gaussian), Robert, Prewitt, Sobel exhibit better performance, respectively. It has been observed that Canny's edge detection algorithm is computationally more expensive compared to LoG(Laplacian of Gaussian), Sobel, Prewitt and Robert's operator.

Keywords: Brain Tumor, Edge Detection, Canny, Laplacian of Gaussian, Robert, Prewitt, Sobel

I. INTRODUCTION

Imaging technology in Medicine made the doctors to see the interior portions of the body for easy diagnosis. It also helped doctors to make keyhole surgeries for reaching the interior parts without really opening too much of the body. CT scanner, Ultrasound and Magnetic Resonance Imaging took over x-ray imaging by making the doctors to look at the body's elusive third dimension. Image processing techniques developed for analyzing remote sensing data may be modified to analyze the outputs of medical imaging systems to get best advantage to analyze symptoms of the patients with ease. There are various advantages of using digital images techniques like data is not changed when it is reproduced again and again and retains originality, enhancement of images makes work easier for physicians to interpret and quick comparison of images. A brain tumor is an abnormal growth of cells within the brain, which can be cancerous or non-cancerous (benign). It is generally caused by abnormal and uncontrolled cell division, normally either in the brain itself (neurons, glial cells (astrocytes, oligodendrocytes, ependymal cells), lymphatic blood vessels), in the cranial nerves (myelin-producing Schwann cells), in the brain envelopes (meninges), skull, pituitary and pineal gland, or spread from cancers primarily located in other organs (metastatic tumors). Brain tumors are of two types: primary and secondary. Primary brain tumors include any tumor that starts in the brain. Primary brain tumors can start from brain cells, the membranes around the brain (meninges), nerves, or glands. Primary brain tumors are classified as: 1) benign; 2) malignant. Benign tumors can be removed, and they seldom grow back. Benign brain tumors usually have an obvious border or edge. They don't spread to other parts of the body. However, benign tumors can press on sensitive areas of the brain and cause serious health problems. Malignant brain tumors are generally more serious and often are a threat to life. They are likely to grow rapidly and crowd or invade the nearby healthy brain tissue. Cancer cells may break away from malignant brain tumors and spread to other parts of the brain or to the spinal cord. They rarely spread to other parts of the body. So efficient and accurate techniques are required for brain tumor detection. In India, totally 80,271 people are affected by various types of tumor (2007 estimates) [2]. Magnetic resonance imaging (MRI) provides detailed information about brain tumor anatomy and acts as an essential pre processing step for tumor detection. Magnetic resonance imaging (MRI), or nuclear magnetic resonance imaging (NMRI), is primarily a medical imaging technique used in radiology to visualize detailed internal structure and limited function of the body. MRI provides much greater contrast between the different soft tissues of the body than computed tomography (CT) does [3].

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include Edge orientation, Noise environment and Edge structure. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. This results in less accurate localization of the detected edges. Not all edges involve a step change in intensity. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual change in intensity [1]. The operator needs to be chosen to be responsive to such a gradual change in those cases. So, there are problems of false edge detection, missing true edges, edge localization, high computational time and problems due to noise etc. Therefore, the objective is to do the comparison of various edge detection techniques and analyze the performance of the various techniques in different conditions.

This paper is divided in five parts. In the second part comparison of edge detection algorithms are discussed. In the third portion advantages and disadvantages edge detection algorithm is discussed are discussed.The next section consists of all the experimental results and finally last section consists of conclusion.

II. METHODS AND MATERIAL

EDGE DETECTION TECHNIQUES

Sobel Operator

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

FIGURE 1: Masks used by Sobel Operator

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient [3].

Robert's Cross Operator

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels as shown in Figure 2. One kernel is simply the other rotated by 90°[4]. This is very similar to the Sobel operator.

+1	0
0	-1

Gx

0	+1
-1	0

Gy

FIGURE 2: Masks used for Robert operator.

Prewitt's operator:

Prewitt operator [5] is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images.

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

FIGURE 3: Masks for the Prewitt gradient edge detector

Zero Crossing Detector

The zero crossing detector looks for places in the Laplacian of an image where the value of the Laplacian passes through zero --- i.e. points where the Laplacian changes sign. Such points often occur at `edges' in images --- i.e. points where the intensity of the image changes rapidly, but they also occur at places that are not as easy to associate with edges. It is best to think of the zero crossing detector as some sort of feature detector rather than as a specific edge detector. Zero crossings always lie on closed contours, and so the output from the zero crossing detector is usually a binary image with single pixel thickness lines showing the positions of the zero crossing points.

The starting point for the zero crossing detector is an image which has been filtered using the Laplacian of Gaussian filter. The zero crossings that result are strongly influenced by the size of the Gaussian used for the smoothing stage of this operator. As the smoothing is increased then fewer and fewer zero crossing contours will be found, and those that do remain will correspond to features of larger and larger scale in the image.

Canny Edge Detection John Canny considered the mathematical problem of deriving an optimal smoothing filter given the criteria of detection, localization and minimizing multiple responses to a single edge. He showed that the optimal filter given these assumptions is a sum of four exponential terms. He also showed that this filter can be well approximated by first-order derivatives of Gaussians. Canny also introduced the notion of non-maximum suppression, which means that given the presmoothing filters, edge points are defined as points where the gradient magnitude assumes a local maximum in the gradient direction. Looking for the zero crossing of the 2nd derivative along the gradient direction was first proposed by Haralick. It took less than two decades to find a modern geometric variational meaning for that operator that links it to the Marr–Hildreth (zero crossing of the Laplacian) edge detector.

3. ADVANTAGE AND DISADVANTAGES OF VARIOUE EDGE DETECTOR

Classical (Sobel, prewitt, Kirsch,…)	Simplicity, Detection of edges and their orientations	Sensitivity to noise, Inaccurate
Zero Crossing(Laplacian, Second directional derivative)	Detection of edges and their orientations. Having fixed characteristics in all directions	Responding to some of the existing edges, Sensitivity to noise
Laplacian of Gaussian(LoG) (Marr-Hildreth)	Finding the correct places of edges, Testing wider area around the pixel	Malfunctioning at the corners, curves and where the gray level intensity function varies. Not finding the orientation of edge because of using the Laplacian filter.
Gaussian(Canny, Shen-Castan)	Using probability for finding error rate, Localization and response. Improving signal to noise ratio, Better detection specially in noise conditions	Complex Computations, False zero crossing, Time consuming

Table1: Advantage and Disadvantages of Various Edge Detector

III. RESULTS AND DISCUSSION

Experimental Result : Visual Comparison of Various Edge Detection Algorithms

Images are obtained by MRI scan of brain and the output of MRI provides gray level images. A gray scale image is a data matrix whose value represents shades of gray. The elements of gray scale matrix have integer values or intensity values in range [0 255]. For applying different techniques, the digital images obtained from MRI are stored in matrix form in MATLAB.

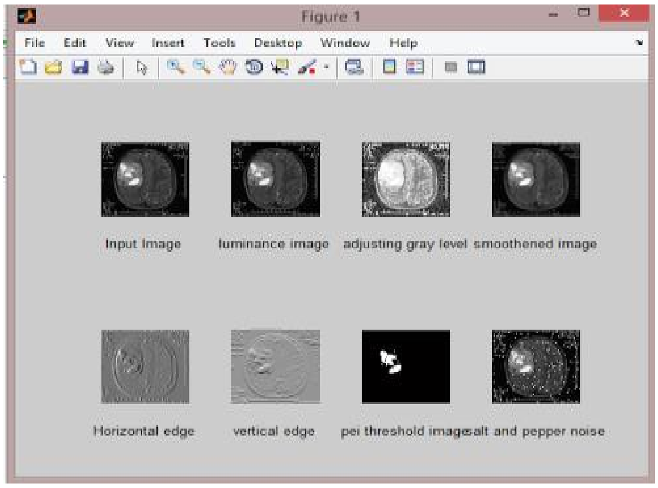

Figure 5 : Image used for edge detection analysis

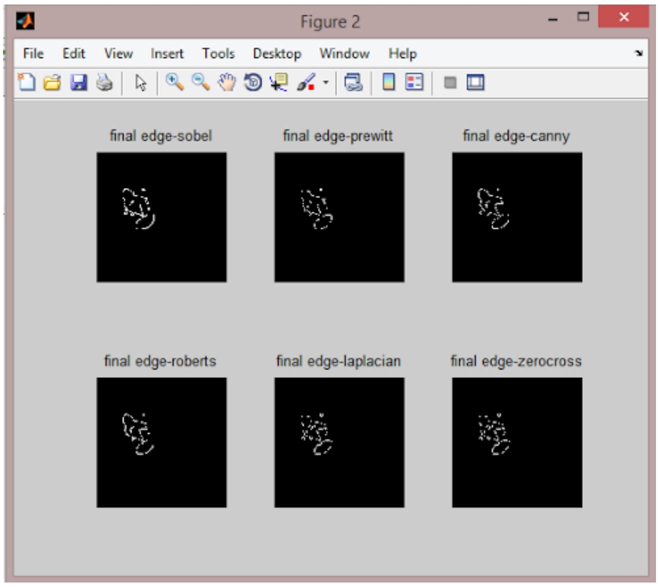

Figure 6 : Comparison of Edge Detection Techniques Original Image (b) Sobel (c) Prewitt (d) Robert (e) Laplacian (f) Laplacian of Gaussian

IV. CONCLUSION

Since edge detection is the initial step in object recognition, it is important to know the differences between edge detection techniques. In this paper we studied the most commonly used edge detection techniques of Gradient-based and Laplacian based Edge Detection. The software is developed using MATLAB 7.0. Canny's edge detection algorithm is computationally more expensive compared to Sobel, Prewitt and Robert's operator. However, the Canny's edge detection algorithm performs better than all these operators under almost all scenarios. Evaluation of the images showed that under noisy conditions, Canny, LoG, Sobel, Prewitt, Roberts's exhibit better performance, respectively.

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