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Image Denoising and Estimation of its Boundary

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ABSTRACT: In thisage of digital technology, almost all processing is done using computer systems. The world around us is inherently analog and three dimensional. Interpreting this 3D data involves vast amounts of processing. Edge Detection & Boundary estimation is a method which enables us to obtain vital information about the actual physical 3D world from a 2D image. A 2D image is converted to grayscaleformat and fed to the Edge Detection and Boundary Estimation algorithm. This algorithm detects the regions with changes in light intensity and marks those regions. Since the changes in light intensity are due to the variations of physical parameters, we are, in effect, obtaining information about the 3D world. The counting algorithm smoothens the edges and counts the number of places at which there are physical parameter variations.

KEYWORDS: Edge Detection, Grayscale, Boundary Estimation, Counting Algorithm

I. INTRODUCTION

Edge detection is a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edge. Edges typically occur on the boundary between two different regions in an image.

The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. It has been studied that the discontinuities in image brightness are likely to correspond to discontinuities in depth, in surface orientation, in texture, in color, changes in material properties and variations in the scene illumination i.e. reflections from various objects and shadows.

Applying an edge detection and boundary estimation algorithm to an image greatly reduces the amount of data that needs to be processed and thus filters out information that may not be relevant, while retaining the important structural properties of the image. Once the edge detection algorithm is successfully applied, the subsequent task of interpreting the information contents in the original image is largely simplified.

Paper is organized as follows. Section II gives a few trends in this field. Section III describes the implementation of this edge detection and boundary estimation algorithm. The flow diagram represents the step of the algorithm with corresponding background explanations. Section IVpresents experimental results showing results of images tested. Section V presents the application areas where this technique can be utilised. Finally, Section VI presents the conclusion.

II. RELATED WORK

In the literature, there are many related procedures that attract attraction including image denoising using median filtering, adaptive smoothing and bilateral filtering with robust estimation. Median filtering is a popular tool used in image processingas it has an ability to remove noise while preserving edges. [5], [6], [7], [8]-[10]. A further improvement was the use of the adaptive smoothing filter as suggested by Saint-Marc *et all* [11] that adapts to the edge structure of the image and avoids pixels located on two different sides of an edge segment from being averaged in local smoothing. This was further generalised to the bilateral filtering procedure by Tomasi and Manduchi [12].

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Easley *et all*[13] propose a shearlet formulation of the total variation method for denoising images. Image denoising based on wavelet transformation and thresholding is also an active research topic and there are several different versions of wavelet transformation and thresholding schemes available [14]-[17]. Gijbels*et all*[18] propose a technique for estimating a discontinuous surface from noisy data based on local linear kernel smoothing. The proposed procedure here for denoising an image and its boundary estimation uses a Canny edge detector to smoothen the image and highlights regions within the image gradient with high spatial derivatives and potential edges are determined using thresholding.

III. EDGE DETECTION & BOUNDARY ESTIMATION

Edge Detection produces a line drawing of a scene from an image of that scene. It enables the extraction of important features from the edges of an image (e.g., the corners, lines, curves etc.).These features can be then used by higher-level computer vision algorithms (e.g., recognition) for further processing based on the application.
In this project, an algorithm was written to detect the edges in the 2D representation of a 3D image and counted the number of edges. The purpose of this was to simplify the interpretation of the image.

Fig. 1 shows the flow diagram of this algorithm's implementation.

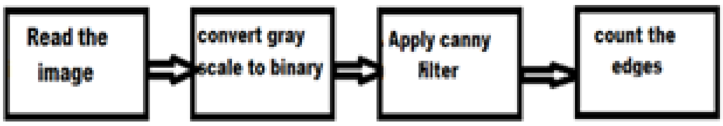

Fig. 1.Flow Diagram

The algorithm steps are summarized as follows.
1. Read the image and convert the color image to grey scale.
2. Converting the grayscale image to a binary image
3. Applying the canny edge detection and boundary estimation algorithms.
4. Counting the number of edges

Step 1. Converting to Grayscale:

A Color image (Fig. 2(a)) is composed of the three primary colors, Red, Green and Blue, therefore it is also called an RGB image. It has 3 values per pixel.
A Grayscale digital image (Fig. 2(b)) is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this kind, also known as black and white, are composed exclusively of shades of gray. It contains intensity values ranging from a minimum (depicting absolute black) to a maximum (depicting absolute white) and in between varying shades of gray. It has only 1 value per pixel.
A common method of color to grayscale conversion is to match the luminance of the grayscale image to the luminance of the color image. To convert any color to a grayscale representation of its luminance, the values of its red, green, and blue (RGB) primaries must be obtained. To encode grayscale intensity in RGB, each of the three primaries can be set to equal the calculated luminance.

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Step 2. Converting to Binary:

A binary image (Fig. 2(c)) is a digital image that has only two possible values for each pixel. Typically the two colors used for a binary image are black and white though any two colors can be used. The color used for the objects in the image is the foreground color while the rest of the image is the background color.
The output image replaces all pixels in the input image with luminance greater than particular level with the value 1 (white) and all other pixels with the value 0 (black). Black color is assigned to all the pixels that have luminosity greater than a threshold level and the others as white.

Step 3. Canny Edge Detection Algorithm

The Canny edge detection algorithm is an optimal edge detector. The edges occurring in images must not be missed or skipped and there should be no responses to non-edges. The distance between the edge pixels as identified by the detector and the actual edge must be minimum, also only one response should be seen for a single edge.

The canny edge detector first smoothens the image to eliminate noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (nonmaximum suppression). The gradient array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds and if the magnitude is below the first threshold, it is set to zero (made a nonedge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the 2 thresholds, then it is set to zero.

Smoothing involves blurring of the image to remove noise. The edges are then marked where the gradients of the image has large magnitudes making sure that only the local maxima are marked. The potential edges are determined by thresholding. The final edges are determined by suppressing all edges that are not connected to a very strong edge (Fig. 2(d)).

Step 4. Counting Algorithm

Region boundaries and edges are closely related, since there is often a sharp adjustment in intensity at the region boundaries. The edges identified by edge detection (Fig. 2(d)) are often disconnected. To segment an object from an image however, one needs closed region boundaries. The desired edges are the boundaries between such objects.
This step finds the boundaries of each object that it finds and stores it. The text function is used to print the number of objects that are found (Fig. 2(e))

IV. EXPERIMENTAL RESULTS

Figures show the result of applying the Canny edge detection and counting algorithm. Fig 2(a) shows the original color image, 2(b) the image after converting it to grayscale, 2(c) represents the binary image, 2(d) shows the Canny edge detection output and 2(e) represents the final image containing the boundaries of each object.

(a) (b) (c)

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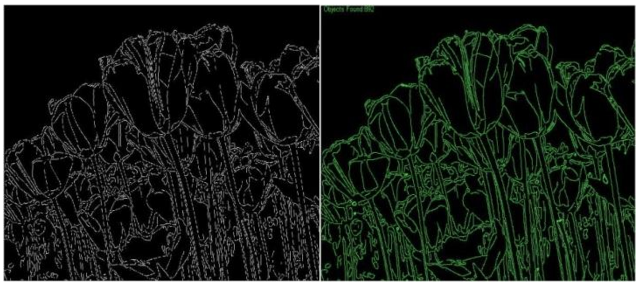

(d) (e)

Fig. 2.Edge Detection and Boundary Estimation (a) Original color image (b) Image after converting to grayscale (c) Image after converting to binary (d) Canny Edge Detection Output (e) Final result containing boundaries of each object

From the original color image, we convert it to a grayscale image that contains only intensity information composed exclusively of shades of grey. Based on thresholding, we obtain a binary image which is then used by the canny edge detection algorithm to obtain the strong edges identified from the binary image and finally, the boundaries of each object is found and stored.

V. APPLICATIONS

Edge detection is an important field in image processing. It can be used in many applications such as segmentation, registration, feature extraction, and identification of objects in a scene.
Edge detection is employed in document image analysis where the goal is to extract printed characters, logos, graphical content, musical scores and map processing where lines, legends and characters are to be found. It is also used to detect a target in scene processing.

Edge Detection and Boundary Estimation is also a useful tool in case of segmentation of various image modalities for non-destructive testing (NDT) applications, such as ultrasonic images, eddy current images, thermal images, X-ray computed tomography (CAT) and laser scanning confocal microscopy. It helps in quality inspection of materials.Edge detection is also used in extraction of edge field, spatio-temperal segmentation of video images and image segmentation in general. Further applications include enhancement of noisy images like satellite images, remote sensing images, mapping of roads and video surveillance.

VI. CONCLUSION

In this paper, an attempt is made to implement image processing using edge detection & boundary estimation and counting algorithms. A Canny filter was used for this purpose. The Canny filter was chosen over other filters such as Sobel, Roberts, Prewitt, etc. because Canny filter method produces smooth and thin edges and less noise per pixel. The counting algorithm was applied to the output of the canny filter in order to make the edges continuous and to distinctly count the number of edges to help in further processing.

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